MORPHOLOGY AND TAXONOMY OF THE SOUTH AFRICAN SPECIES OF THE GENUS MARGARODES (HEMIPTERA : MARGARODIDAE), WITH DETAILED STUDIES ON THE BIOLOGY OF TWO VINE INFESTING SPECIES.

by

C.A. DE KLERK

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Promotor: Prof. J.H. Giliomee

Co-promotor: Dr. Y. Ben-Dov

ABSTRACT

An account of the general morphology of the various stages of nine species of the genus Margarodes is given. Two new species i.e. M. upingtonensis and M. vredendalensis are described and seven other species occurring on vines and grasses in South Africa are redescribed. Where available, immature stages are also described or redescribed. Taxonomic keys are given for the identification of the nymphs of the cyst stage of six species and to the adult females of ten species. The distribution of all the South African Margarodes species, in particular those infesting vines, is outlined.

Various aspects on the biology of M. capensis (Giard) and M. vredendalensis sp.n. which are of economic importance to viticulture, were studied under laboratory and controlled conditions as well as in the field.

The cyst stage of both species occurred throughout the year at various depths to 1,2 m in the soil, the majority occurring at a depth of 46 - 60 cm. Only a small percentage of cysts developed to adult females annually, and both species reproduced parthenogenetically. The average longevity of adult females of M. capensis was 24 days and an average of 251 eggs was oviposited per female. In M. vredendalensis an average of 507 eggs was oviposited per female during an average longevity of 40 days. Oviposition was inhibited in both species at a temperature of 10°C while 40°C proved to be lethal to the females. Eggs were normally produced at 25 and 30°C as well as at relative humidities of 32,5 and 75,5 per cent. Eggs were also oviposited in dry as well as in wet soil.

Eggs of both species hatched at a relative humidity of 100 per cent but not at 75,5 and 32,5 per cent. Incubation of eggs was inhibited at 10°C and at 40°C the eggs died. Normal development of eggs to larvae occurred at 25 and 30°C. Eggs hatched in very dry soil, as well as in very wet soil. The incubation period of eggs of M. capensis was between 34 and 43 days, while that of M. vredendalensis was between 36 and 45 days.

First instar larvae of M. capensis were covered with a cyst wall after two months and moulting to the cyst stage occurred between two and three months after hatching from the eggs.

C O N T E N T S

1. INTRODUCTION AND REVIEW OF LITERATURE

Since the erection of the genus Margarodes by Guilding (1829), and until it was assigned the type-genus of the Margarodidae by Morrison (1927), numerous species had been described in this genus. The first comprehensive revision of the genus was by Morrison (1928) who placed it in the Margarodini, one of five tribes which he recognized in the Margarodidae. The latest taxonomic study of the group on a worldwide basis was by Jakubski (1965) who regarded the Margarodini of Morrison (1928) as a separate family - Margarodidae - with some 70 species distributed amongst 10 genera.

These species occur almost throughout the world on a wide range of host plants. Vine infesting species have, however, only been reported from North and South America and from South Africa. Margarodes vitis (Phillippi) is one of the three American species found on vines and it is of great economic importance. Severe damage occurs especially in Chilé where approximately 600 ha of vineyards are infested (Fauré & Pinto, 1959). As a result of the economic importance of this species, detailed studies were made of its morphology and biology (Ruiz Leal, 1954; Jakubski, 1965; Gonzalez, Kido, Marin & Hughes, 1969; Barnes, Wargo & Marin, 1969). The other two known vine infesting species are Margarodes meridionalis Morrison in California and Margarodes brasiliensis Hempel in Wille from South America. The extent of the damage caused by them is still unknown but according to Barnes, Asch & Deal (1954) M. meridionalis is considered to be a potential threat. Descriptions of these species are given by McDaniel (1965) and Jakubski (1965).

Some aspects of the biology of M. meridionalis are described by Barnes et al. (1954) as well as Thomas (1959).

According to Brain (1915) and Munro & Fouche (1936) six Margarodes species occur in South Africa. Four of these are grass infesting, viz. Margarodes newsteadi Brain, 1915, Margarodes peringueyi Brain, 1915, Margarodes ruber Brain, 1915 and Margarodes trimeni Giard, 1897, while Margarodes capensis (Giard), 1897 and Margarodes greeni Brain, 1915 were found on vine roots. A closely related species, Sphaeraspis prieskaensis Jakubski, 1965 was also found on vine roots in South Africa while Neomargarodes pilosus Jakubski, 1965 was found on roots of grasses (Jakubski, 1965). An undetermined species of Margarodes of which no material could be obtained, was reported from sugar cane (Carnegie, Dick & Harris, 1974). Burger (1970) reported that an undetermined margarodid occurs on vine roots in the Olifants River irrigation area. An unidentified species of Margarodes was also found on roots of kikuju grass during 1974 in Upington (A. Calitz, personal communication).

According to De Klerk (1975), Margarodes is an increasing pest in the Orange River and Olifants River irrigation areas where numerous vineyards are infested resulting in vines dying in patches. The problem has become very serious, especially in the Malmesbury area where several vineyards have been completely destroyed.

The above-ground symptoms of Margarodes infested vines largely correspond to those of phylloxera infested vines. The first symptom is a gradual decline in vitality, increasing with the course of years. The shoots become shorter and

thinner, with smaller leaves. Later one or more arms of the vine die (Fig. 1.1) and finally the whole vine. The duration of the process varies greatly. Damage usually starts in patches (Fig. 1.2) which gradually become larger, probably due to slow migration of larvae and adult females in the soil. In the event of a severe and uniform infestation the whole vineyard shows a decline in vitality. No characteristic galls or other symptoms are found on the roots as is the case with phylloxera.

At present no pesticide is registered for the control of Margarodes in vineyards and no rootstock resistance to this pest is known. According to De Klerk (1975), Margarodes attacks and destroys three of South African's best phylloxera resistant rootstocks, viz. Richter 99, 101-14 and Rupestris du Lot.

In the cyst stage the insects can remain inactive in the soil for many years (Ferris, 1919) and with the establishment of a new vineyard the vines could be attacked again. Inasmuch as the species occurring in America have a wide range of host plants (Gonzalez et al. 1969) there is a possibility that this may also be the case in South Africa. Rotation cropping will therefore not solve the problem. A vineyard of 9 ha in the Malmesbury area, for example, was uprooted because of the occurrence of poorly growing patches. After four years of rotation cropping a new vineyard was planted on this soil. After a further four years similar symptoms occurred, and it was later found that these symptoms were caused by a Margarodes infestation. Eleven years later this vineyard was also uprooted since production had dropped from approximately 5,3 tons per ha at the age of five years to 2,1 tons per ha after eleven years.

Fig. 1.1 (above) : A vine with poor growth and dead arms resulting from an infestation of M. capensis in the Malmesbury area.

Fig. 1.2 (below) : A patch of dead vines in a vineyard in the Malmesbury area caused by an infestation of M. capensis.

In the cyst stage the insects are highly resistant to unfavourable conditions and the "drowning" technique, if practically applicable, would therefore not be successful. Soil cultivation with the object of destroying the cysts has been applied in a certain vineyard in the Malmesbury area. The result was merely a considerable enlargement of the infected spot.

It would therefore seem that an infestation is permanent and that infected land may become unsuitable for economic vineyard cultivation. This is particularly serious where practically a whole farm is infested with Margarodes.

Except for a brief description of the life-history of Sphaeraspis prieskaensis Jakubski by Du Toit (1975), virtually nothing is known of the biology of South African Margarodidae. As information on the biology is essential for the formulation of a control programme, one of the objects of this study was to clarify some aspects of the biology of two economically important vine infesting species, viz. Margarodes capensis (Giard) in the Malmesbury area and Margarodes vredendalensis sp.n. in the Vredendal area. These two areas are situated in the Western and North Western Cape respectively. In order to identify these and other species found on vines and grasses, they were compared with description and redescriptions of South African species by Brain (1915) and Jakubski (1965). Descriptions by Brain were very short and incomplete while the morphological characters described by Jakubski were not consistantly used for every species. Consequently, the species investigated could not be distinguished on the basis of these descriptions and thus redescriptions were made from type material of all the vine and grass infesting species

(except N. pilosus of which inadequate material was available). Two species were found to be new, viz. Margarodes vredendalensis and Margarodes upingtonensis.

The South African species were assigned to four genera by Jakubski (1965). In the course of this study, however, it was almost impossible to employ his key for genera nor could his distinctions between the various genera be interpreted adequately. This is due to the fact that he based his generic concepts to a great extent on features of the first instar larvae and of the cysts, despite the fact that these were not available to him for all the taxa concerned. Therefore until the taxonomy of this group of ground pearls is better understood all the South African species are treated as members of the genus Margarodes.

2. MORPHOLOGY OF MARGARODES SPECIES IN SOUTH AFRICA

2.1. MATERIAL AND METHODS

Specimens on slides were borrowed from the National Collection of Insects, Plant Protection Research Institute, Pretoria (PPRI) and from the United States National Museum for Natural History, Washington, (USNM). Sources of other material are indicated in the descriptions. Mounted specimens were deposited in the collection of the Oenological and Viticultural Research Institute, Stellenbosch (OVRI).

The specimens were preserved in a mixture of 4 parts 70% ethyl alcohol and 1 part glacial acetic acid and mounted individually on microscope slides with the aid of a stereo microscope. The procedure used for mounting the adult females was as follows:

1. The specimens were transferred from the alcohol acetic acid mixture to 10% KOH and heated.
2. The body contents were expelled while in KOH through a small hole, pierced on the dorsal side near the head, by slightly pressing on the body.
3. The specimens were then transferred to distilled water, heated and their body contents further expelled.
4. After the specimens became yellow to brown, a few droplets of glacial acetic acid were added to the water and the specimens were left for 10 to 15 minutes.
5. The specimens were then transferred to pure glacial acetic acid and left overnight to become transparent.
6. A few droplets of a solution of acid fuchsin stain were added and the specimens were left for a few hours or

overnight. If the specimens were not stained satisfactory after this period, they were tranferred to pure acid fuchsin stain for a few hours.

7. The specimens were then transferred to lactophenol and left overnight.
8. Next, the specimens were transferred to glacial acetic acid for 10 to 15 minutes.
9. Finally the specimens were transferred to oil of cloves for 10 to 15 minutes.
10. The specimens were then mounted individually in canada balsam.
11. The slides were permanently marked with a diamond point pencil.
12. Slides were kept in a drying oven at 40°C for about two weeks before labelling.

Nymphs of the cyst stage were mounted according to the same method after the cyst wall was dissolved by heating in 14% NaOH. First instar larvae were also mounted according to this method but without expelling the body contents manually.

Drawings were made by using a pamphot drawing apparatus. Enlargements were drawn by using a drawing tube and a phase contrast microscope. Measurements were made with an eyepiece screw micrometer. Measurements are given in microns unless otherwise mentioned; averages are followed by the range.

Each plate has a central drawing of the whole specimen with the left half representing the dorsal surface and the right half the ventral surface. The drawings are not made to the same scale in all the species. Letterings are explained in the text at the end of each description.

The electron microscope photos were taken of unmounted material with the aid of a scanning electron microscope.

2.2 GENERAL MORPHOLOGY OF THE FIRST INSTAR LARVAE

PLATE 1

GENERAL APPEARANCE: The first instar larvae of the two Margarodes species described in this study viz. M. capensis and M. vredendalensis are elongated (Fig. A) and very small, varying in length from 0,8 to 1,0 mm and 0,2 to 0,3 mm in width. They are creamy white in colour with large antennae and two very long apical setae at the posterior end of the abdomen. The abdomen has 8 distinct segments and the last is invaginated apically.

DORSAL SURFACE: Very small, inconspicuous setae which are only visible at a 1000 x magnification, occur in low numbers on the whole dorsal surface of the body. Spines and derm pores are absent in both species.

VENTRAL SURFACE: Setae of similar shape to those that occur on the dorsal surface are also present in low numbers on the whole ventral surface. On the last abdominal segment one short, rigid seta and one very long apical seta (Fig. B) are found on each side of the anus. In both species two multilocular derm pores (Fig. C) are situated near the labium, with numerous microloculi (Fig. a) in an outer circle and 3 macroloculi in the centre (Fig. b). Spines are absent.

ANTENNAE (Fig. D): The antennae of both species are 4 segmented, geniculated and with the two apical segments together club-shaped. The basal segment is 1½ times as long as wide. The second segment is about half as long as the basal segment. The third segment is 1½ times as wide as long. All these segments bear small setae. The last segment is

2½ times as long as the third, rounded at the apex; 5 long setae are distributed around the middle while 5 to 6 long setae, 2 cylindrical fleshy setae and 2 club-shaped fleshy setae are placed apically.

FRONT LEGS (Fig. E): The coxa is as long as wide with 2 to 4 minute setae. The trochanter is small with 0 to 3 minute setae as well as 2 large sensory pores on each of the posterior and anterior sides. The femur is the largest segment of the leg with 1 to 3 minute setae on each of the posterior and anterior sides. The tibia and tarsus each have 3 to 4 setae. The claw is curved, smooth on its inner surface, sclerotized except at the base with one long seta-like digitule on each of the posterior and anterior sides.

MIDDLE AND HIND LEGS (Fig. F): The middle and hind legs are similar to each other in size and shape. They differ from the front legs in that the claws are almost straight and longer than those of the front legs. The femora of the hind legs are also narrower than those of the front legs.

THORACIC SPIRACLES (Fig. G): Two pairs of thoracic spiracles with circular openings occur in both species. One small pore is situated near the opening on the posterior side of each spiracle (Fig. c). The atrium is cylindrical.

ABDOMINAL SPIRACLES (Fig. H): Seven pairs of abdominal spiracles are present in both species. The second and third pairs are slightly smaller than the thoracic spiracles, but the first and last 4 pairs are much smaller and inconspicuous.

MOUTHPARTS: The sclerotized clypeo-labral complex (Fig. I) is situated between the front and middle legs. The stylets

form an oblong loop which is approximately 1½ times as long as the body when extended. The labium (Fig. K) is situated posterior to the clypeo-labral complex, opposite the first pair of thoracic spiracles. It is sclerotized and bears 4 to 8 short setae.

ANAL OPENING (Fig. L): The anal opening is circular and situated sub-apically on the last abdominal segment of the ventral side.

No significant morphological differences could be detected between the larvae of M. capensis and M. vredendalensis.

PLATE AND LETTERING

Plate 1: General morphology of the first instar larvae (with labium shown to one side)

A = dorsal and ventral sides of body
B = apical seta
C = multilocular derm pore
D = antenna
E = front leg
F = hind leg
G = thoracic spiracle
H = abdominal spiracle
I = clypeo-labral complex
J = stylets
K = labium
L = anal opening
a = microloculus
b = macroloculus
c = small pore

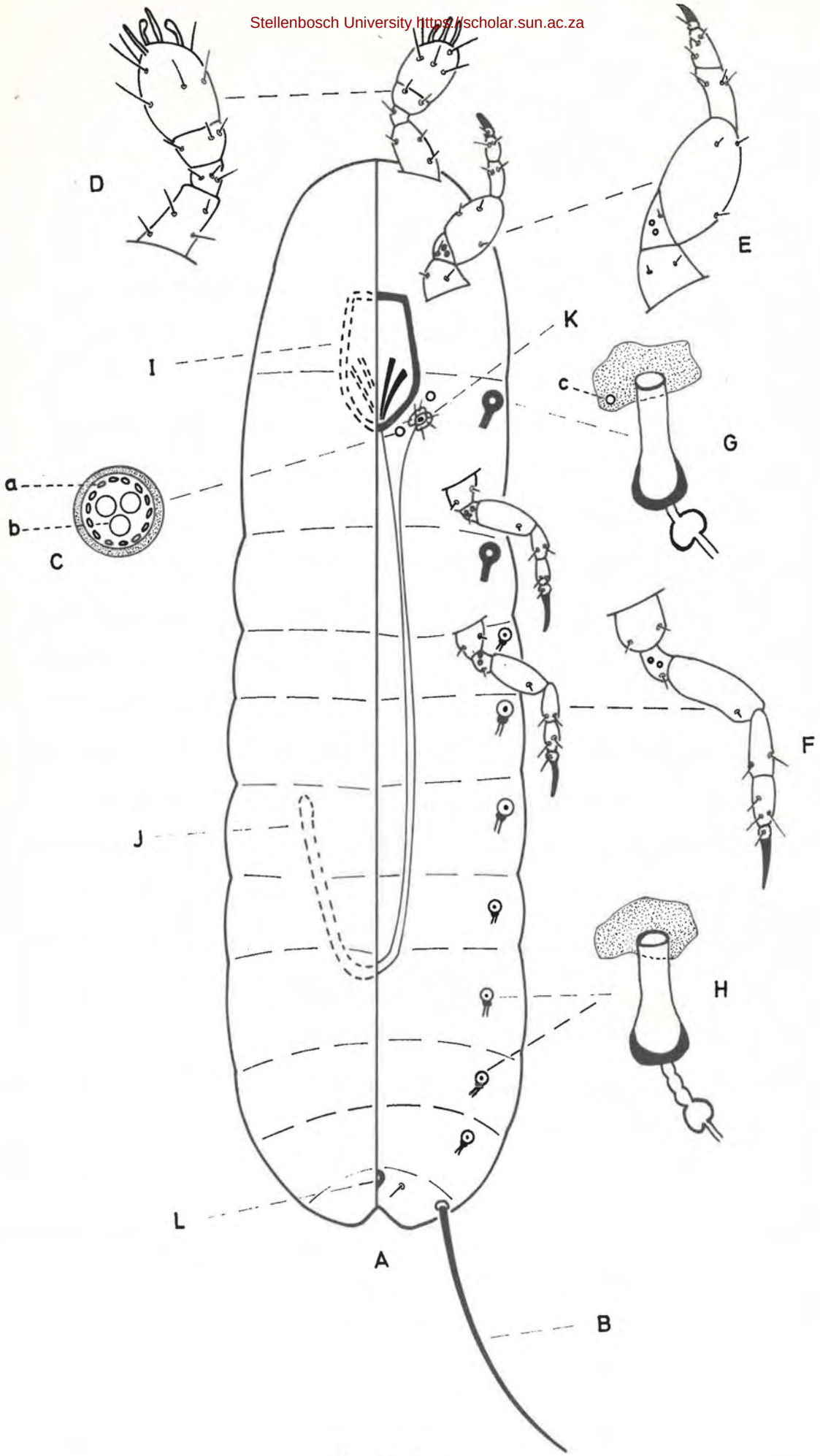


PLATE 1

2.3 GENERAL MORPHOLOGY OF THE NYMPHS OF THE CYST STAGE

PLATE 2

GENERAL APPEARANCE: The cysts of the various species of Margarodes described in this study differ considerably in outer appearance. The cyst wall is usually spherical except for M. trimeni where it is oval and narrower at one end. The maximum size of the cysts of the different species varies from 2,5 to 8,6 mm in diameter. Great variation in size could also occur among cysts of the same species. The outer surface is rough or smooth while the colour could be light to dark brown, yellow or white in the various species. The colours are dull except for M. trimeni which has an iridescent lustre. The outer surface of the cysts are without segmentation although transverse lines could be discerned ventrally in M. greeni, giving the impression of true segmentation. On the outer surface of the cyst a small, smooth, flat area with the opening for the stylets is visible (Figs. 1, 2 and 3). The cyst wall of most of the species is thick and very hard consisting of numerous layers (Fig. 4) but thin and soft in M. upingtonensis and M. greeni. The position of the spiracles is only noticeable after wax secretion had started.

DORSAL SURFACE: The dorsal surface of the encysted nymphs of all the species described is devoid of any structures.

VENTRAL SURFACE: Eyes, setae, spines and legs are absent in all the species described.

ANTENNAE: The antenna is only a small rounded protrusion, usually situated in a deep pit with 1 to 4 minute, bluntly

pointed, fleshy setae at the distal end (Fig. 5).

MOUTHPARTS: The mouthparts consist of a sclerotized clypeo-labral complex which is situated opposite the thoracic spiracles and 4 very long stylets with the labium situated posteriorly near the clypeo-labral complex. The stylets form an oblong loop and is approximately as long as the body when it is extended except for M. trimeni and M. upingtonensis in which it is twice as long as the body. In M. greeni the stylets form a semi-circular loop which is 2 to 3 times as long as the body when extended. The labium is sclerotized with short setae.

THORACIC SPIRACLES: The nymphs of all the species described have two pairs of thoracic spiracles situated opposite the clypeo-labral complex. On the posterior side and near the opening of each spiracle there are 2 to 4 very small inconspicuous pores situated near each other on a small sclerotized plate. The atrium is cylindrical with multilocular pores, varying from 4 to $\pm$ 30 in number in the different species.

ABDOMINAL SPIRACLES: Seven pairs of abdominal spiracles occur in all the species except in M. trimeni and M. greeni which have 6 pairs. The first pair are situated more marginally and they are of the same size or only slightly smaller than the thoracic spiracles except for M. trimeni in which they are 2 to 3 times smaller. The abdominal spiracles become smaller towards the posterior end of the body but in M. greeni they are all of the same size. The atrium is cylindrical with multilocular pores, varying from 3 to $\pm$ 30 in number in the different species. The opening of the spiracles are circular and wax threads are produced through

it (Fig. 6).

PORES: Multilocular derm pores with numerous microloculi in an outer circle and 3 to 4 macroloculi in the centre occur in numbers of 4 to 29 around the labium of all the species except in M. trimeni and M. greeni. M. upingtonensis is the only species in which multilocular derm pores also occur near the openings of the thoracic spiracles. They are grouped together in numbers of 2 to 7 on the anterior side of the opening, each with 6 to 12 microloculi in an outer circle and 2 to 3 macroloculi in the centre.

ANAL OPENING: This is circular and situated sub-apically on the ventral surface with variable numbers of cicatrices arranged in different positions around the opening. Cicatrices are shallow indentations with a circular opening and with a narrow sclerotized band around the opening. In most species they occur in a line between the anus and the last pair of abdominal spiracles. In M. prieskaensis and M. upingtonensis, however, they extend to the fifth pair of abdominal spiracles. They are arranged in a single line except in M. capensis and M. upingtonensis where they occur in vertical pairs. In M. vredendalensis they are arranged in a line of vertical pairs as well as singularly around the anus.

GENITAL SCAR: Visible as a transverse line situated anteriorly near the anal opening.

PLATE AND FIGURES

Plate 2: General morphology of the nymph of the cyst stage (with labium shown to one side).

Figure 1: Outer surface of the cyst of M. capensis with opening for stylets (x16).

Figure 2: Opening for stylets on smooth flat area in M. capensis (x54).

Figure 3: Opening for stylets on outer surface of cyst wall in M. capensis (x480).

Figure 4: Cross section through cyst wall of M. capensis (x86).

Figure 5: Antenna of M. capensis in deep pit and with fleshy setae apically (x1000).

Figure 6: Opening of abdominal spiracle of M. capensis with wax thread (x1000).

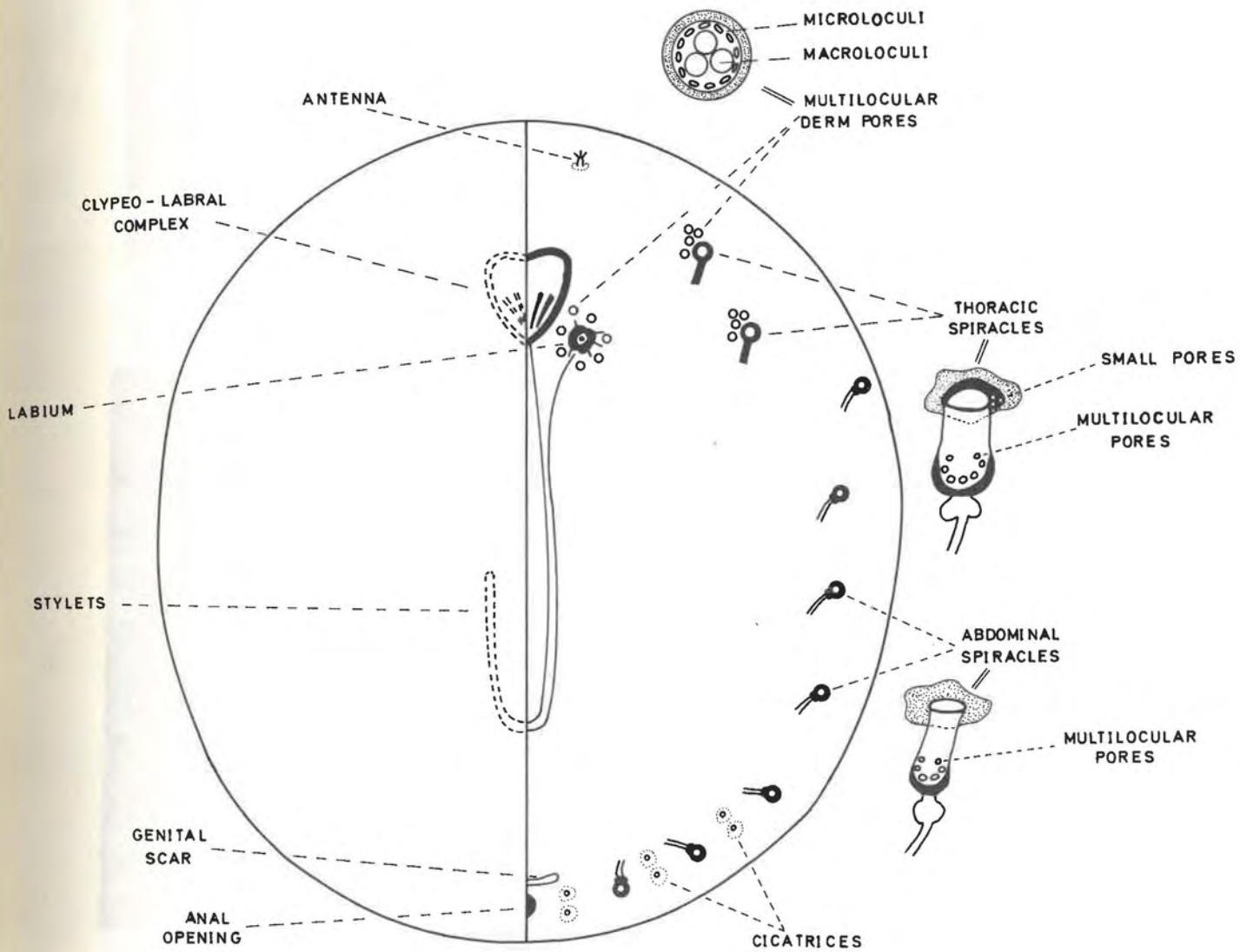
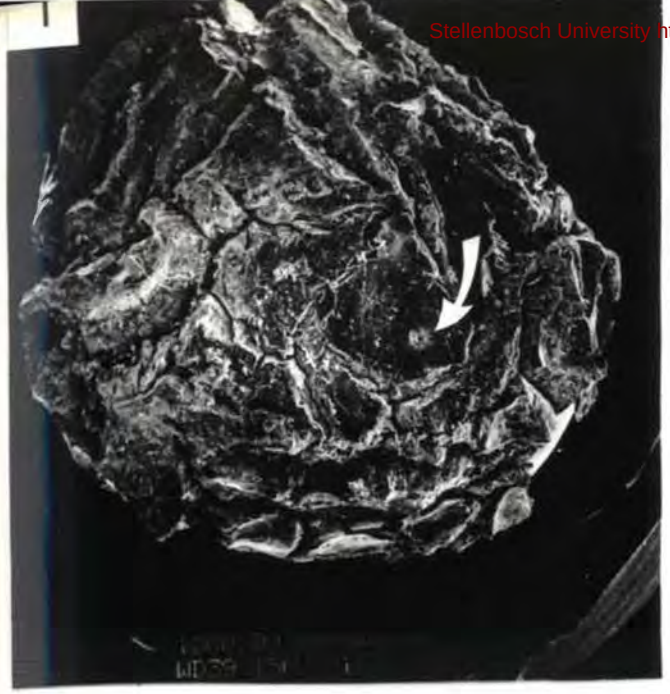
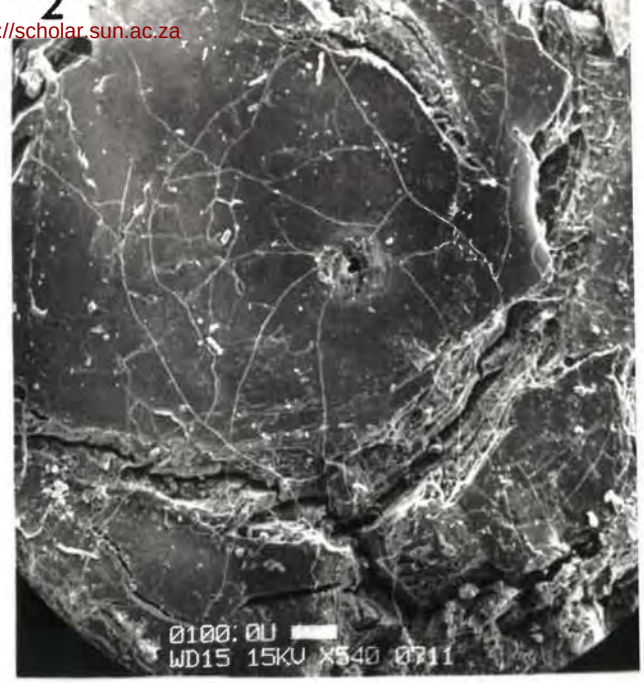


PLATE 2





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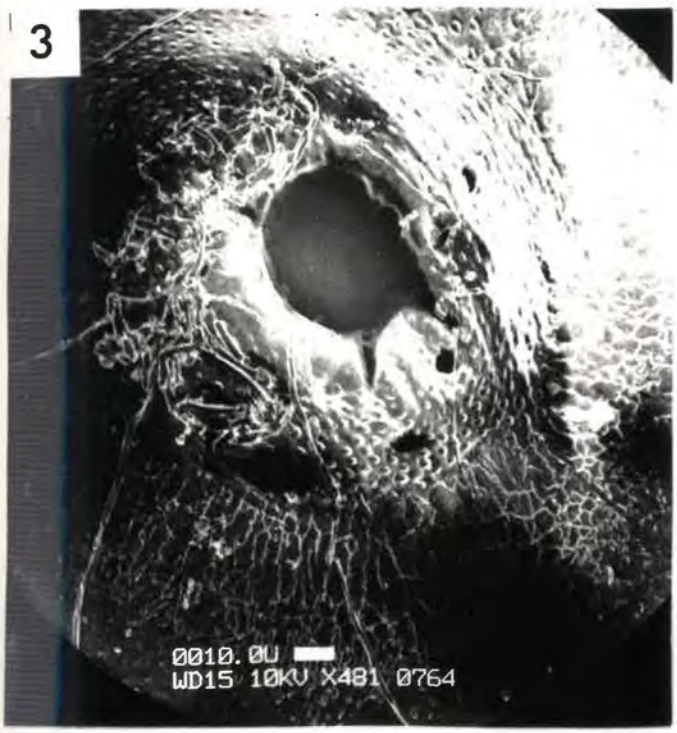

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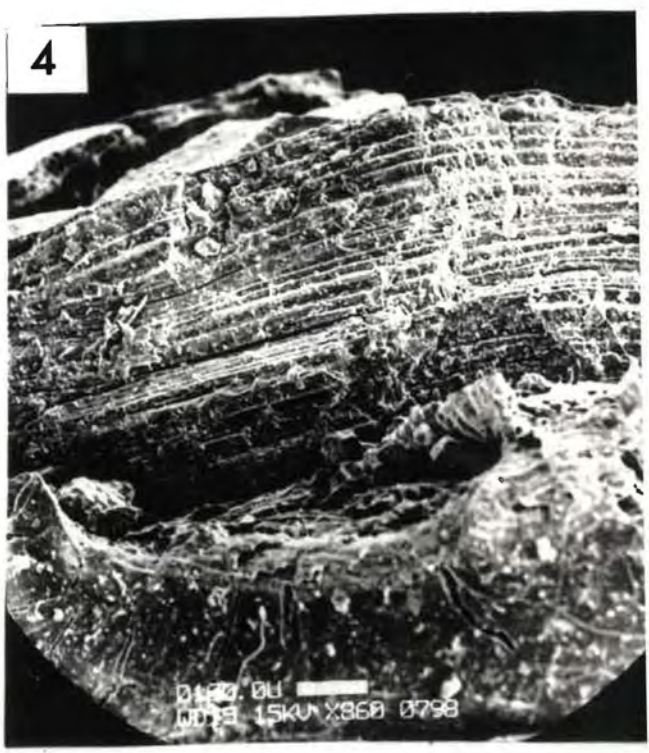

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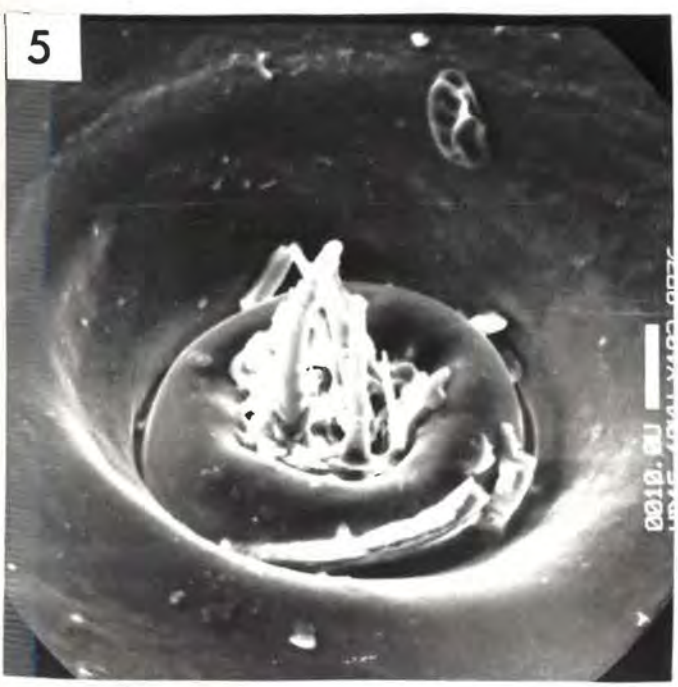

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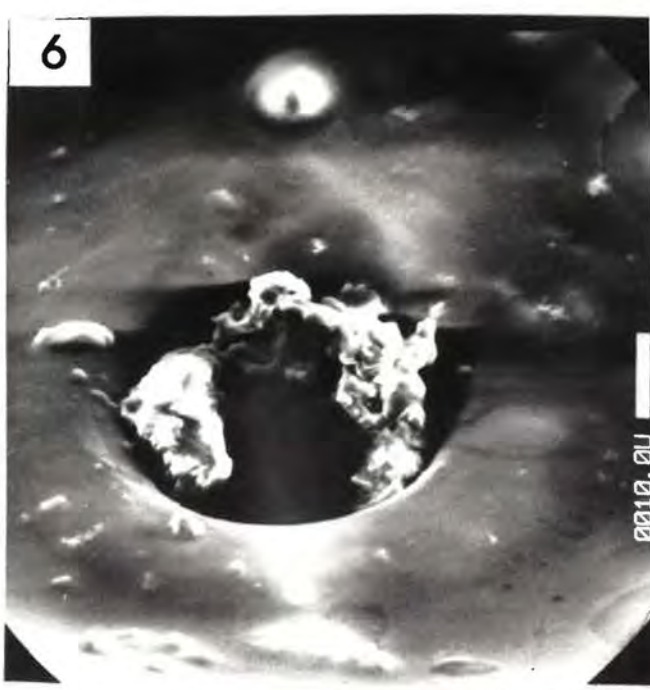

2.4 KEY TO THE NYMPHS OF THE CYST STAGE

A key to the six species of which cysts were available, is presented below.

1. With 7 pairs of abdominal spiracles; multilocular derm pores present around labium 2
   With 6 pairs of abdominal spiracles; multilocular derm pores absent around labium 5

2. Multilocular derm pores present around thoracic spiracles ..... Margarodes upingtonensis sp. n.
   Multilocular derm pores absent around thoracic spiracles 3

3. Cicatrices present from the fifth abdominal spiracles to the anus ..... Margarodes prieskaensis (Jakubski)
   Cicatrices present only between the last pair of abdominal spiracles and the anus 4

4. Cicatrices less than 10 in number; arranged in pairs ..... Margarodes capensis (Giard)
   Cicatrices more than 10 in number; arranged in pairs as well as singularly ..... Margarodes vredendalensis sp. n.

5. Cyst with metallic lustre; maximum size 6 mm in diameter ..... Margarodes trimeni Giard
   Cyst without metallic lustre; maximum size 2,5 mm in diameter ..... Margarodes greeni Brain

2.5 GENERAL MORPHOLOGY OF THE ADULT FEMALES

PLATE 3

GENERAL APPEARANCE: The adult females of the various species of Margarodes described in this study are oval in shape (Plate 3A) with distinct segmentation on both the dorsal (Fig. 7) and ventral sides (Fig. 8). The average length of the different species varies from 2,5 to 7,8 mm. Great variation in size may also occur among females of the same species. They are white or yellow in colour. The front legs are much larger than the middle and hind legs and all have sclerotized, dark brown claws. The body is covered with setae and in M. vredendalensis and M. prieskaensis these setae are very long and more numerous than in the other species, giving them a hairy appearance.

BODY SETAE: Different kinds of setae occur on the body. The long setae (Plate $3B^1$; Fig. 9a) are thin and hairlike, varying in average length in most of the different species from 64 to 152 micron. In M. prieskaensis and M. vredendalensis, however, these setae are exceptionally long and their average length is 350 and 453 micron respectively. These long setae occur on the dorsal as well as the ventral surfaces of the whole body.

Short setae (Plate $3B^2$; Fig. 9b) are thin but rigid and their average length in most of the species varies from 35 to 48 micron, except for M. vredendalensis and M. prieskaensis in which their average length is 83 and 98 micron respectively. These short setae are situated amongst the long setae on the ventral and dorsal surfaces of the body, except in M. ruber, M. trimeni, M. upingtonensis and M. prieskaensis where they

are absent on the dorsal surface. Their numbers are much lower than those of the long setae. On the abdomen the long and short setae occur over the whole surface of each segment (Fig. 10), except for M. greeni and M. upingtonensis where they are situated on the central line of each segment.

M. vredendalensis is the only species where a third kind of seta (medium setae) occurs, their length being intermediate to that of long and short setae (Plate $3B^3$).

BODY SPINES: The longest spines occur on the anterior part of the body, varying in average length in the different species from 12 to 39 micron. In most of the species these spines are bluntly pointed (Plate $3C^1$; Fig. 11), but in M. peringueyi, M. ruber and M. greeni they are sharply pointed (Plate $3C^2$) and in M. prieskaensis they are not pointed but club-shaped (Plate $3C^3$). These spines become more bluntly pointed, thicker and shorter from the anterior part of the body towards the posterior end of the abdomen (Plate $3C^4$; Fig. 12) with the exception of M. greeni and M. vredendalensis where the size of the spines remains the same. The spines on the posterior part of the abdomen in M. prieskaensis are, however, completely different from those in the other species as their apices are bulbous in form (Plate $3C^5$).

Spines occur in variable numbers amongst the setae on the dorsal as well as the ventral sides of the body. Their density is high, except in M. greeni and M. capensis.

DERM PORES: The derm pores are circular (Plate $3D^1$; Fig. 13), and their average diameter in the diffent species varies from 10 to 14 micron. They are multilocular in that they have 8 to 18 microloculi (Plate 3a) arranged in an outer

circle and 3 to 11 macroloculi (Plate 3b) arranged in an inner circle.

Within this inner circle a single macroloculus (Plate 3c) could be present or absent in the different species. M. prieskaensis is the only species with up to 3 central macroloculi (Plate $3D^2$). These derm pores are distributed in variable numbers amongst the setae and spines (Fig. 14). In M. newsteadi, M. greeni and M. upingtonensis they are distributed on the dorsal and ventral surfaces of the whole body. In M. capensis, M. vredendalensis and M. prieskaensis these pores are absent on the anterior part of the body and occur only from the metathorax towards the posterior end of the abdomen. In M. peringueyi they are absent on the head and prothorax. In M. trimeni they are found only on the abdomen and in M. ruber they occur dorsally on the whole body, but ventrally only on the head. During oviposition these derm pores secrete wax threads (Fig. 15).

ANTENNAE: The antennae of all the species described in this study have 8 segments, except for M. ruber which has 10. The basal segment (scape) of all the species is twice as wide as long. The second antennal segment (pedical) is half as long as the third segment or even three times shorter (M. trimeni), but of the same length in M. peringueyi, M. greeni and M. vredendalensis. All the flagellar segments, except the last, are all about of the same length but diminish gradually in width (Plate 3E; Fig. 16), each having variable numbers of long hairlike setae and short bluntly pointed fleshy setae distributed around the distal end (Fig. 17). The last segment is longer and narrower than the others

and rounded at the apex where long hairlike setae and short fleshy setae are situated (Fig. 18). The average length of the antenna of the different species varies between 354 and 729 micron.

FRONT LEGS: The front legs are much larger than the middle and hind legs. As the coxa and trochanter are usually covered by folds of the body (Fig. 19) they are very difficult to observe. The femur is very large, ranging in length from an average of 274 to 815 micron and in width from 265 to 775 micron. All the segments of the front legs have variable numbers of setae and the claws are heavily sclerotized except basally (Plate 3F).

MIDDLE AND HIND LEGS: Both pairs are similar in size and shape. The coxa is large with a sclerotized apodeme. The trochanter is a narrow segment with variable numbers of sensory pores. The femur is much larger than the other segments, varying in average length from 169 to 358 micron and in width from 106 to 305 micron. All the segments of the legs have setae that vary in length and in numbers (Plate 3G; Fig. 20). The claw is heavily sclerotized, except basally, curved and smooth on the inner surface, but serrated in M. peringueyi. The average length of the claw varies between 150 and 292 micron, except for M. ruber, M. greeni and M. peringueyi in which the claw is much shorter, varying between 74 and 80 micron.

THORACIC SPIRACLES (Plate 3H): All the species studied here have two pairs of thoracic spiracles with circular or elongated openings (Fig. 21). On the posterior side and near the opening of each spiracle there are 2 to 5 small

pores grouped together on a small sclerotized plate (Plate 3d). The atrium is cylindrical and the average diameter varies between 46 and 159 micron. In the atrium 2 to 18 multilocular pores (Plate 3e) are arranged in a circle on the peritreme wall just inwards to the atrium and 3 to 5 smaller simple pores (Plate 3f) in one or more inner circles. The latter pores are usually very difficult to observe and their numbers are therefore not a good character for taxonomic identifications.

ABDOMINAL SPIRACLES (Plate 3I): In M. upingtonensis, M. capensis, M. vredendalensis and M. prieskaensis 7 pairs of abdominal spiracles are found but the rest of the species have only 6 pairs. The first two pairs are half as small as the thoracic spiracles but in M. greeni, M. vredendalensis and M. prieskaensis they are only slightly smaller while they are 3 times smaller in M. newsteadi and M. trimeni. The abdominal spiracles become smaller from the first to the last pair in M. peringueyi, M. capensis, M. vredendalensis and M. prieskaensis but in the rest of the species they are all of about the same size. The opening is circular or oval (Fig. 22). The atrium is cylindrical, varying in average diameter from 20 to 32 micron except in M. upingtonensis, M. capensis, M. vredendalensis and M. prieskaensis where it varies from 52 to 143 micron. Large multilocular pores (Plate 3g) are arranged in a circle on the peritreme wall just inwards to the atrium, varying in number from 3 to 8, except in M. vredendalensis and M. prieskaensis where their numbers vary from 10 to 18. Smaller simple pores (Plate 3h) are arranged in one or more inner circles, varying from 3 to 30 in number except in M. new-

steadi, M. ruber and M. greeni where they are absent. These multilocular and simple pores are usually very difficult to observe and their numbers are thus not a good character for taxonomic identifications.

MOUTHPARTS: True mouthparts are absent in all the species. Folds occur in the body (Fig. 8) at the place where mouthparts occur in other stages.

GENITAL OPENING: The genital opening can be seen as a transverse fissure situated anteriorly near the anal opening (Plate 3J; Fig. 23) with distinct lips which could be bare or covered with short rigid setae.

ANAL OPENING: This is circular or oval, sclerotized and situated sub-apically on the ventral surface in a small naked area (Plate 3K; Fig. 24). No spines are present on its margin.

PLATE, LETTERING AND FIGURES

Plate 3: General morphology of the adult females

A = dorsal and ventral sides of body

B^1 = long seta

B^2 = short seta

B^3 = medium seta

C^1 = bluntly pointed spine

C^2 = sharply pointed spine

C^3 = spine with rounded apex

C^4 = club-shaped spine

C^5 = bulbous spine

D^1 = multilocular derm pore, with 0 - 1 central loculus

D^2 = multilocular derm pore, with 1 - 3 central loculi

E = antenna

F = front leg

G = hind leg

H = thoracic spiracle

I = abdominal spiracle

J = genital opening

K = anal opening

a = microloculus

b = macroloculus

c = central loculus

d = small pores on small sclerotized plate

e = multilocular pore

f = simple pore

Figure 7: Dorsal surface of M. capensis (x15).

Figure 8: Ventral surface of M. capensis (x20).

Figure 9: Long setae (a), short setae (b) and spines (c) on ventral surface of M. capensis (x440).

Figure 10: Distribution of long setae and spines on the whole surface of an abdominal segment of M. capensis (x100).

Figure 11: Bluntly pointed spines on anterior part of body of M. capensis (x1500).

Figure 12: Shorter, thicker and more bluntly pointed spines than those anteriorly occur on posterior end of abdomen of M. capensis (x1500).

Figure 13: Multilocular derm pore in M. capensis (x2600).

Figure 14: Multilocular derm pores amongst spines and setae in M. capensis (x400).

Figure 15: Wax secretion of a multilocular derm pore of M. capensis (x2400).

Figure 16: Antenna of M. capensis (x130).

Figure 17: Sixth antennal segment of M. capensis with long hairlike setae and short fleshy setae distributed around distal end (x480).

Figure 18: Last antennal segment of M. capensis with long hairlike setae and short fleshy setae placed apically (x480).

Figure 19: Front legs of M. capensis with coxae and trochanters hidden behind body folds (x48).

Figure 20: Hind leg of M. capensis (x150).

Figure 21: Outer opening of thoracic spiracle of M. capensis (x300).

Figure 22: Outer opening of abdominal spiracle of M. capensis (x300).

Figure 23: Genital opening of M. capensis covered with short rigid setae and situated near the anal opening (x94).

Figure 24: Anal opening of M. capensis situated on small naked area (x240).

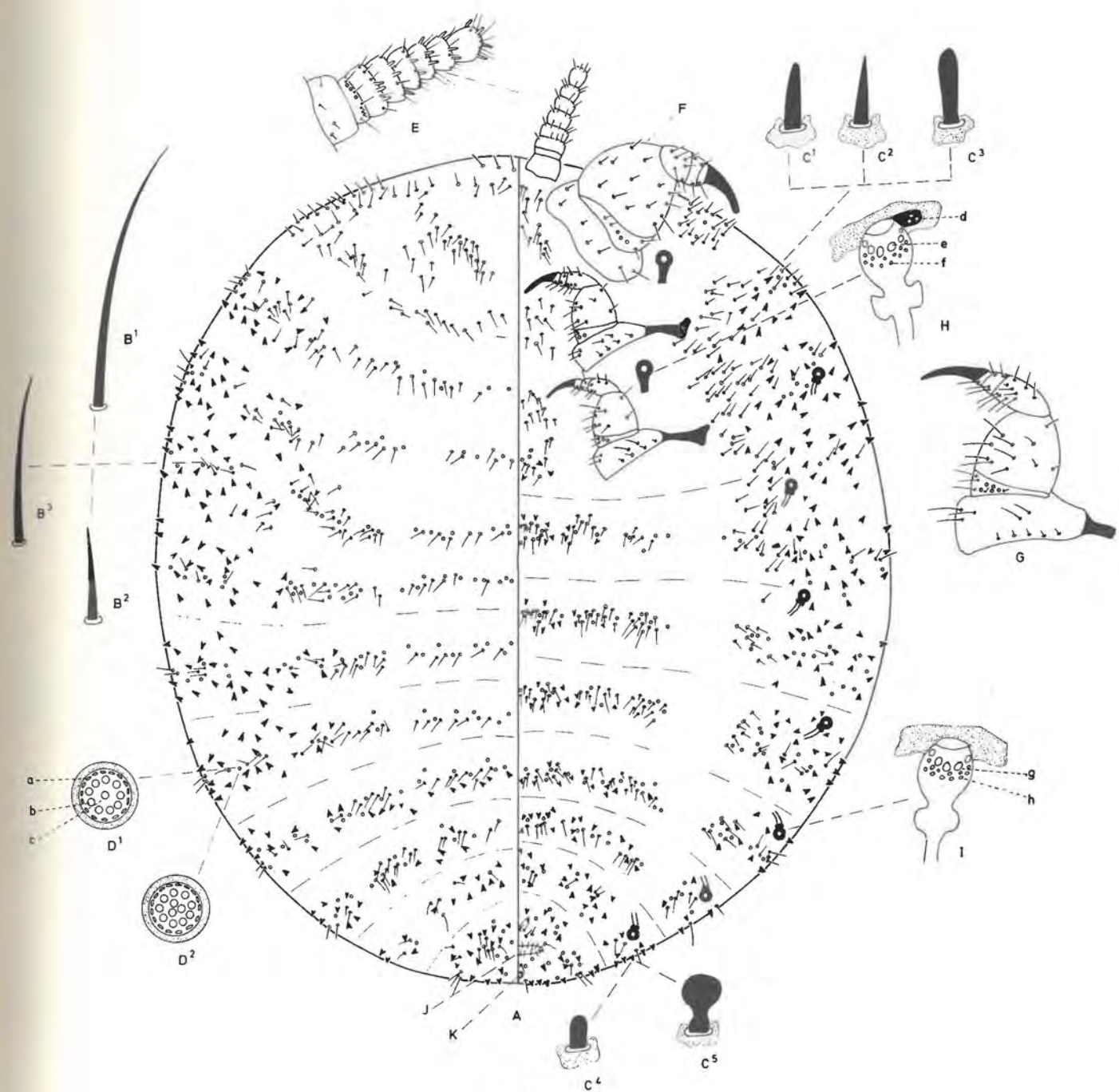

PLATE 3

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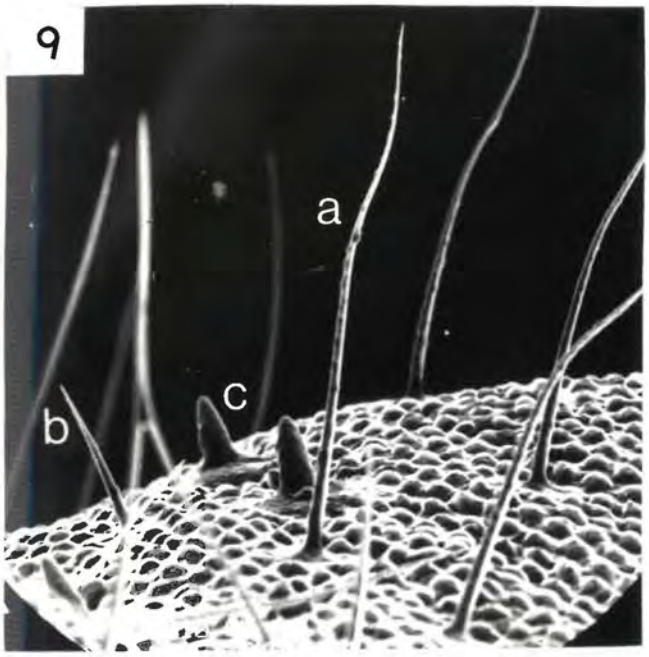

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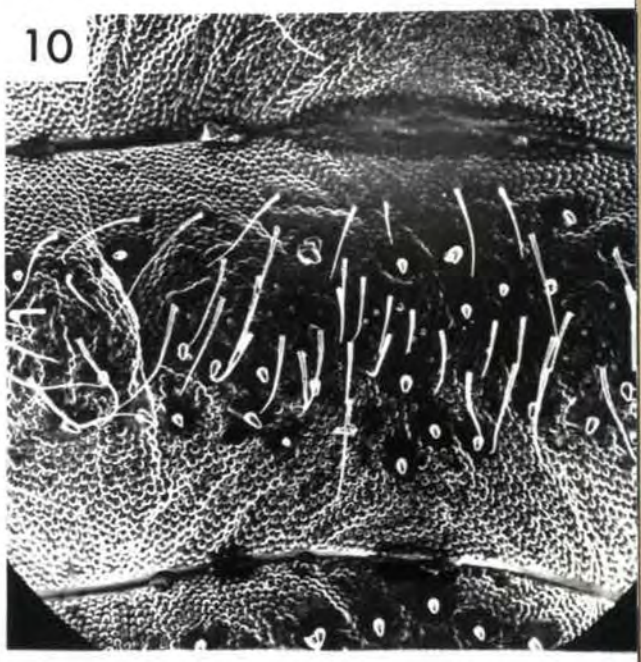

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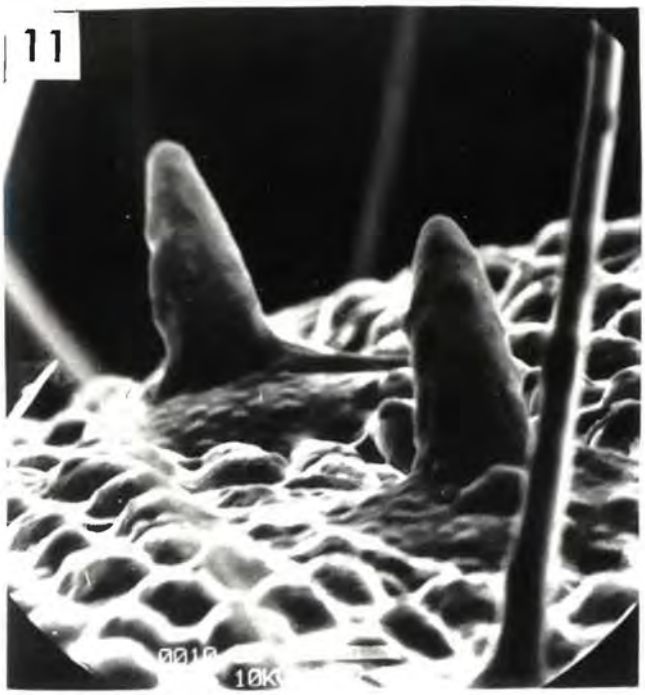

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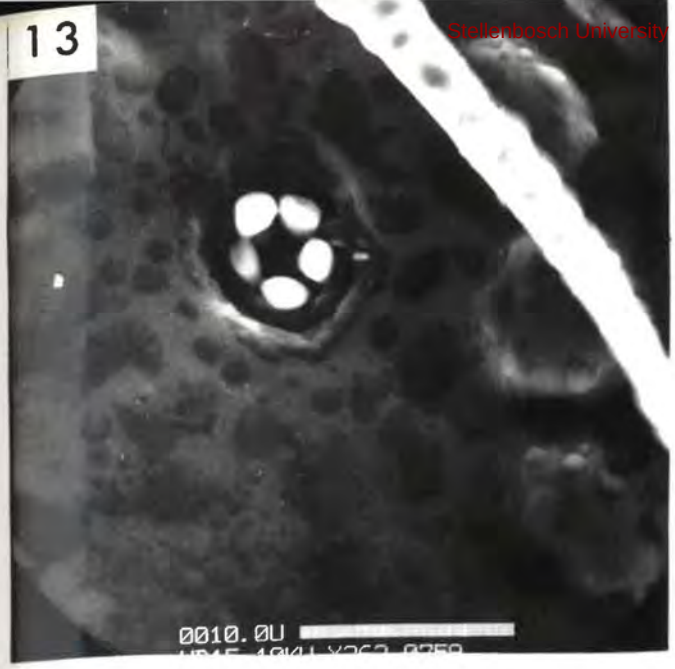

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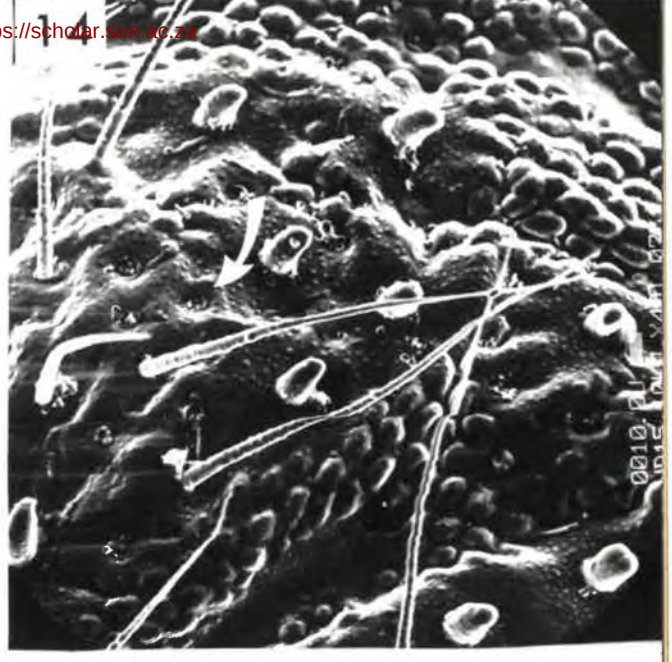

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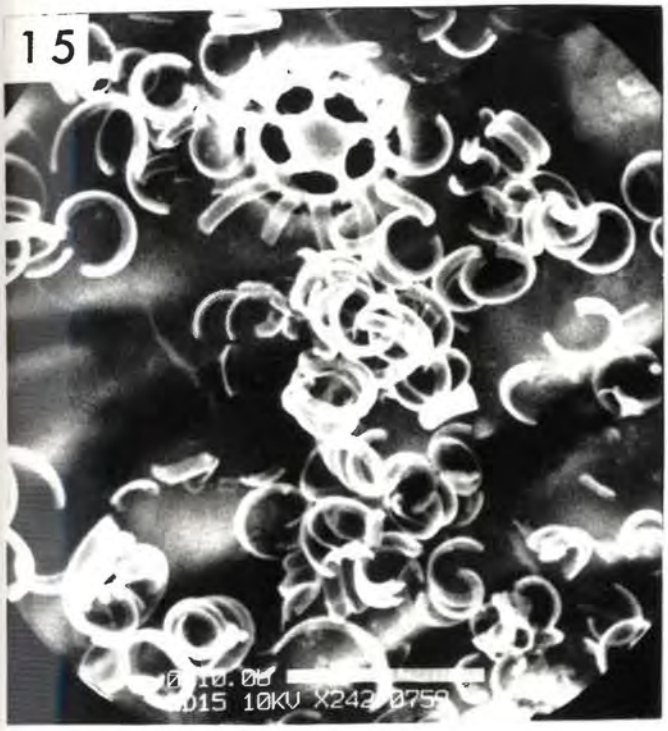

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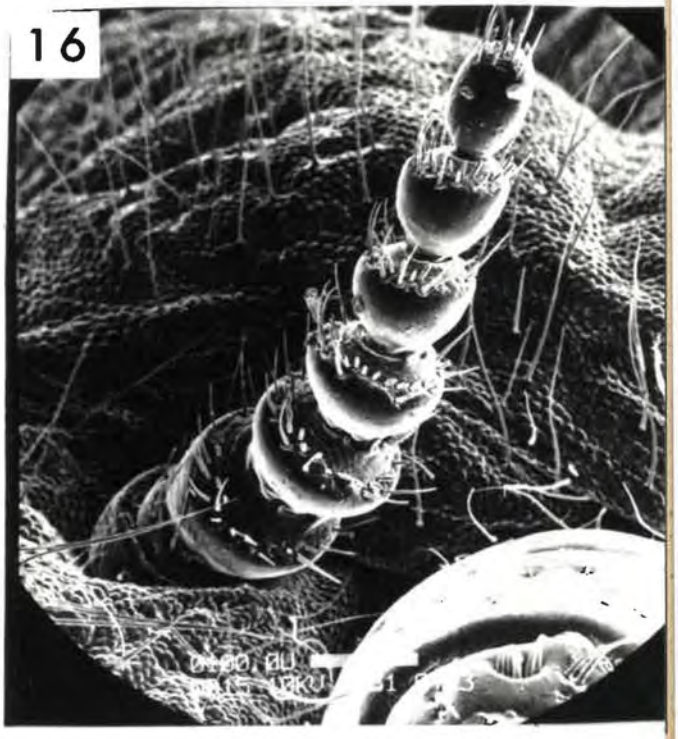

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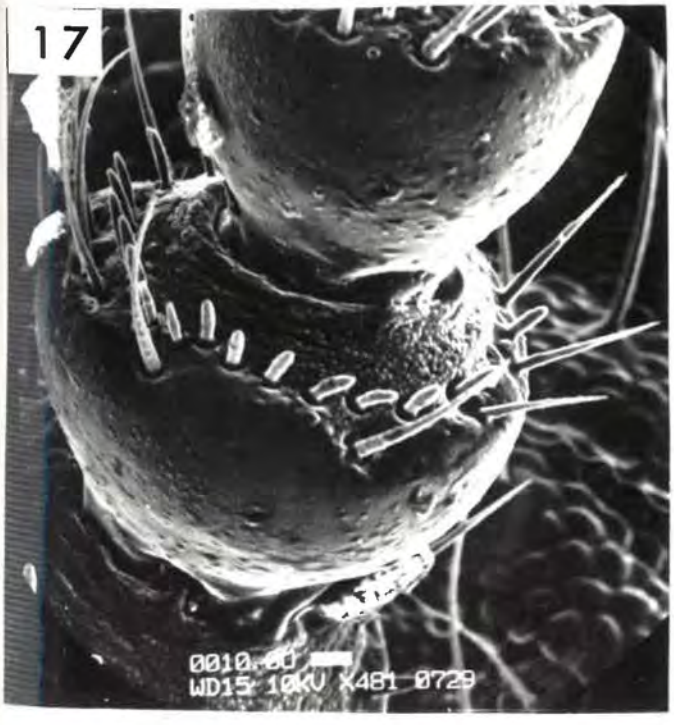

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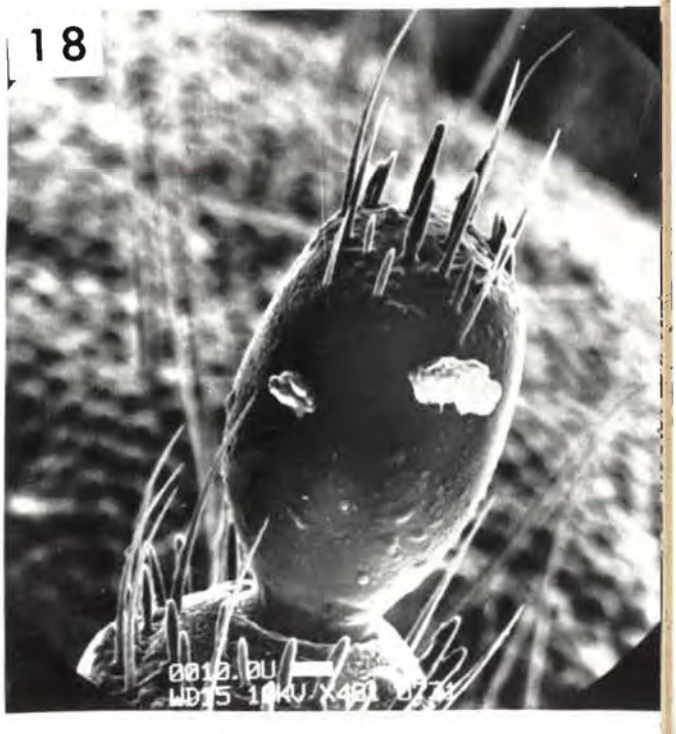

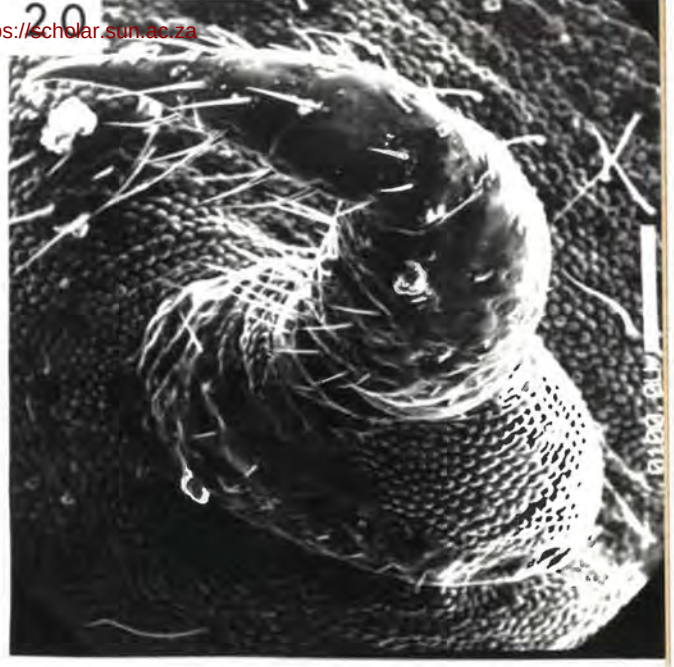

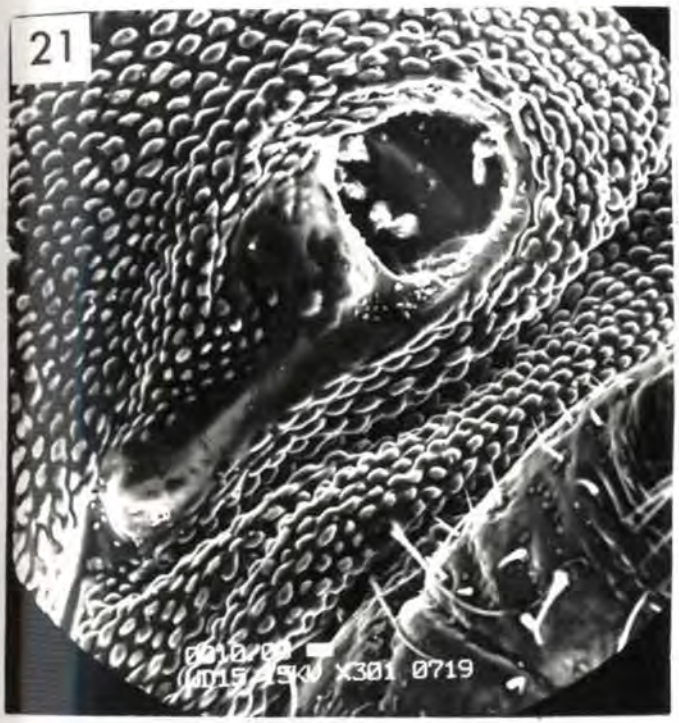

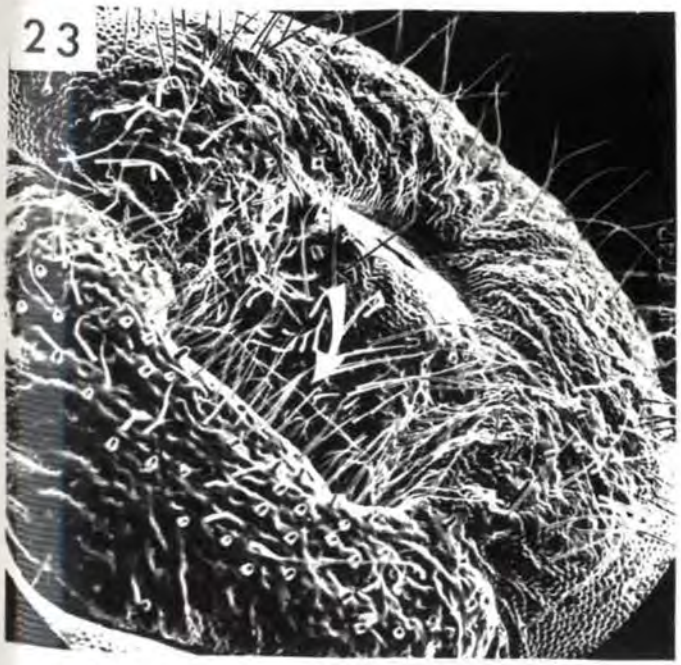

2.6 KEY TO THE ADULT FEMALES

1. With 8 pairs of abdominal spiracles .....
..... Margarodes pilosus (Jakubski)
With 7 pairs of abdominal spiracles 2
With 6 pairs of abdominal spiracles 5

2. Bulbous spines present at posterior end of abdomen ..... Margarodes prieskaensis (Jakubski)
Bulbous spines absent at posterior end of abdomen 3

3. Ventral setae very long (380 - 490 micron); antennal segment II as long as segment III .....
..... Margarodes vredendalensis sp. n.
Ventral setae short (108 - 194 micron); antennal segment II half as long as segment III 4

4. Multilocular derm pores distributed over whole body; spines absent on prothorax .....
..... Margarodes upingtonensis sp. n.
Multilocular derm pores absent on head, pro- and mesothorax; spines present on whole thorax .....
..... Margarodes capensis (Giard)

5. Multilocular derm pores absent on ventral surface of abdomen ..... Margarodes ruber Brain
Multilocular derm pores present on ventral surface of abdomen 6

6. Multilocular derm pores absent on head and prothorax 7
Multilocular derm pores present on whole body .. 8

7. Multilocular derm pores present only on abdomen, mostly from third or fourth segment on both dorsal

and ventral sides. Claws of middle and hind legs long (182-201 micron), slightly curved and smooth on inner surface .... Margarodes trimeni Giard

Multilocular derm pores on abdomen as well as metathorax ventrally and meso- and metathorax dorsally. Claw of middle and hind legs short (71-100 micron), strongly curved and rough on inner surface .... Margarodes peringueyi Brain

8. Spines: Low density, present only ventrally on marginal and median areas of metathorax and abdomen. Absent in median areas of dorsal side ..... Margarodes greeni Brain

Spines: High density, present on whole thorax and abdomen on dorsal and ventral sides ..... Margarodes newsteadi Brain

2.7 DESCRIPTION OF THE DIFFERENT MARGARODES SPECIES

MARGARODES CAPENSIS (GIARD), 1897

Margarodes (Sphaeraspis) capensis Giard , 1897 : 685

Margarodes capensis (Giard); Brain, 1915 : 184

Coccionella capensis (Giard); Lindinger, 1954 : 615

Sphaeraspis capensis (Giard); Jakubski, 1965 : 118

This species was first described from cysts collected by C.P. Lounsbury in the Malmesbury and Worcester areas (Giard, 1897).

EGG

Newly laid eggs are with a smooth glossy-white surface; elongated; 593 (425 - 875) long, 227 (200 - 250) wide; with one end more bluntly pointed.

FIRST INSTAR LARVA

GENERAL APPEARANCE

First instar larva creamy white in colour, elongated with antennae and legs clearly visible.

DESCRIPTION

Body elongated; 0,89 (0,84 - 0,91) mm long and 0,24 (0,22 - 0,27) mm wide. Abdomen with 8 distinct segments; last segment invaginated apically.

DORSAL SURFACE

Setae: Minute, rigid and inconspicuous setae are distributed sparsely and irregularly on head, thorax and abdomen.

Spines absent.

Pores absent.

VENTRAL SURFACE

Setae: Minute, rigid and inconspicuous setae occur sparsely and irregularly on head, thorax and abdomen. Two short rigid setae are found one on each side of anus on last abdominal segment. Two very long (213,2; 185,2 - 245,4) apical setae occur on last abdominal segment.

Spines absent.

Pores: Two multilocular derm pores situated near labium, with numerous microloculi in an outer circle and 3 macroloculi in the centre.

Antennae 4 segmented; geniculated, with club-shaped flagellum; distance between antennae approximately the same as width of basal segment. Segment I 1½ times as long as wide, with 4 - 6 short setae. Segment II half as long as segment I and slightly narrower, with 3 - 4 short setae. Antenna bends outwards almost rectangularly at this segment. Segment III 1½ times as wide as long, with 4 - 5 short setae. Segment IV 2½ times as long as segment III; rounded at apex; with 5 long setae distributed around the middle as well as 5 long setae, 2 cylindrical fleshy setae and 2 club-shaped fleshy setae placed apically.

Antennal segment	Length	Width
I	34,5 (32,1 - 36,9)	24,5 (22,6 - 28,6)
II	20,9 (16,7 - 23,8)	17,6 (15,6 - 19,0)
III	19,7 (19,0 - 21,4)	28,4 (23,8 - 29,8)
IV	51,0 (47,6 - 52,4)	37,1 (35,7 - 39,3)

Front legs placed 143,0 (127,3 - 159,5) apart from middle legs. Coxa with 2 - 3 minute setae. Trochanter small with 0 - 2 minute setae; 2 large sensory pores on each of posterior and anterior sides. Femur large, with 1 - 3 minute setae on each of posterior and anterior sides. Tibia with 3 - 4 setae. Tarsus with 3 - 4 setae and with a small rounded protrusion proximally. Claw short, curved, smooth on inner surface, heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Segment	Length	Width
Coxa	31,2 (27,4 - 33,3)	32,6 (32,1 - 33,3)
Trochanter	21,2 (13,0 - 23,8)	20,2 (17,9 - 21,4)
Femur	58,5 (57,1 - 59,5)	35,3 (29,8 - 38,1)
Tibia	34,0 (32,1 - 35,7)	16,4 (14,3 - 19,0)
Tarsus	20,0 (19,0 - 22,6)	15,7 (14,3 - 16,7)
Claw	23,1 (17,9 - 27,3)	

Middle and hind legs: Middle legs placed 95,0 (94,2 - 95,8) apart from hind legs. Both pairs similar in size and shape. Coxa with 2 - 3 minute setae. Trochanter small, with 1 - 2 minute setae; 2 large sensory pores on each of posterior and anterior sides. Femur large, with 1 - 2 minute setae on each of posterior and anterior sides. Tibia with 2 setae. Tarsus with 2 - 3 setae and with a small rounded protrusion proximally. Claw long, almost straight, smooth on inner surface, heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Segment	Length	Width
Coxa	28,8 (27,4 - 34,5)	27,9 (26,2 - 29,8)
Trochanter	14,3 (11,9 - 17,9)	17,2 (16,7 - 17,9)
Femur	50,2 (47,6 - 53,6)	21,6 (20,2 - 22,5)
Tibia	31,7 (28,6 - 34,5)	12,7 (11,9 - 15,5)
Tarsus	24,5 (20,2 - 28,6)	11,4 (10,7 - 11,9)
Claw	34,5 (32,2 - 36,9)	

Thoracic spiracles: Two pairs, with circular openings; one small pore near opening on posterior side. Atrium cylindrical.

Abdominal spiracles: Seven pairs; second and third pair slightly smaller than thoracic spiracles; first pair and last four pairs inconspicuous and much smaller than second and third pairs.

Mouthparts: Sclerotized clypeo-labral complex situated between front and middle legs. Stylets forming an oblong loop; approximately 1½ times as long as body when extended. Labium situated posterior to clypeo-labral complex and opposite first thoracic spiracles; sclerotized; with 6 - 8 short setae.

Anal opening circular; sclerotized; situated sub-apically on last abdominal segment on the ventral surface.

NYMPH OF THE CYST STAGE (Plate 4)

GENERAL APPEARANCE

Almost spherical, and varying in size to a maximum of 6,3 mm in diameter. Cyst wall thick and very hard. Outer surface rough and barklike (Fig. 25); light to dark brown in colour. Outer layers peel off easily, revealing a bright yellow colour.

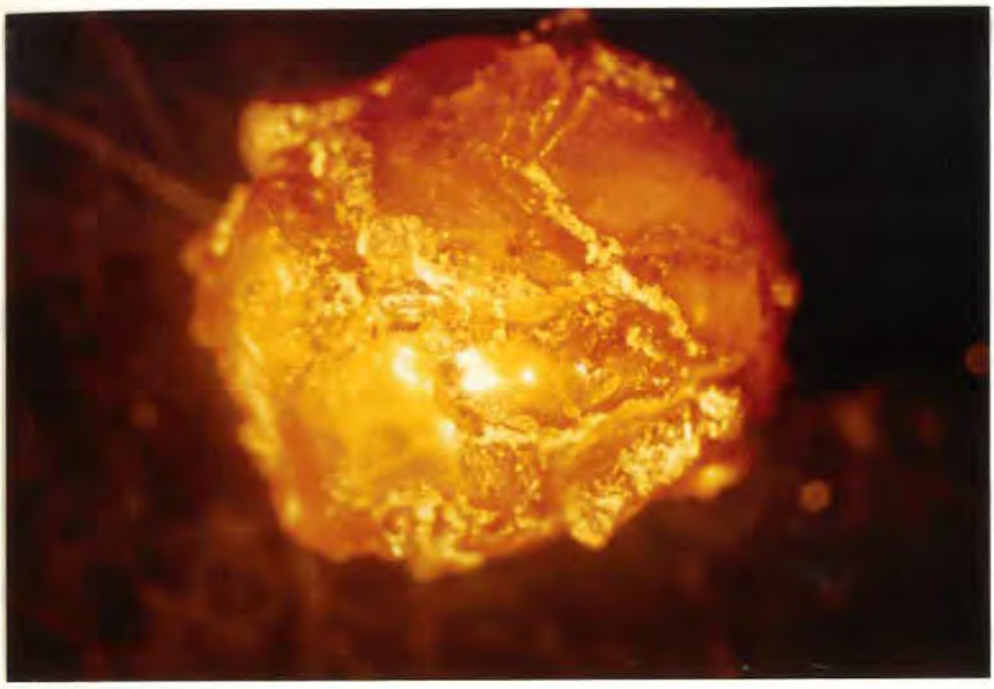

Fig. 25 : Cyst of Margarodes capensis (Giard)

DESCRIPTION

Antennae: Small rounded protrusion in deep pit with 4 minute, bluntly pointed, fleshy setae at distal end.

Mouthparts: Sclerotized clypeo-labral complex situated opposite thoracic spiracles. Stylets forming an oblong loop; approximately as long as body when extended. Labium sclerotized; with 6 - 8 short setae.

Pores: 4 - 9 multilocular derm pores situated around labium, each with numerous microloculi in an outer circle and 3 macroloculi in the centre.

Thoracic spiracles: Two pairs with circular openings; 3 - 4 small pores grouped together next to opening on posterior side. Atrium 75,8 (61,1 - 115,7) in diameter with about 25 multilocular pores.

Abdominal spiracles: Seven pairs; first pair slightly smaller than thoracic spiracles and situated more marginally; size decreases towards posterior end of abdomen. Atrium of first pair 64,3 (55,6 - 77,8) in diameter with about 25 multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 8 - 9 cicatrices, usually arranged in a line of 2 vertical pairs on each side of the anus. Cicatrices occur only between anus and last pair of abdominal spiracles.

Genital scar a transverse line situated anteriorly near anal opening.

ADULT FEMALE (Plate 5)

GENERAL APPEARANCE

Adult female varies greatly in size. Dirty white to yellowish in colour. Body sparsely covered with short hairlike setae. Segmentation plainly visible on both ventral and dorsal sides.

DESCRIPTION

Body (Fig. A) oval; 5,18 (3,84 - 7,52) mm long; 4,28 (3,12 - 6,00) mm wide; with distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 125,4 (111,1 - 185,2) long; distributed on whole surface of dorsum; slightly more numerous on head and at posterior part of abdomen; distributed over whole surface of each abdominal segment.

Short setae (Fig. C): 47,6 (33,3 - 59,3) long; rigid; situated amongst the long setae and distributed as the latter.

Spines (Fig. D): Bluntly pointed; 23,6 (17,8 - 31,2) long; few spines occur in marginal area of thorax, becoming less numerous towards posterior end of abdomen; absent in median area of whole body.

Pores (Fig. E): Multilocular derm pores circular, 11,8 (10,7 - 14,5) in diameter; variation in diameter similar over entire abdomen; with 14 - 18 microloculi in an outer circle, 4 - 8 macroloculi in inner circle and with a central loculus; absent on head and thorax; few pores occur in marginal and median areas of abdomen, increasing in number towards posterior end of abdomen.

VENTRAL SURFACE

Long setae (Fig. G): 152,0 (108,3 - 193,5) long; more numerous than on dorsum except for narrow area between median and marginal areas of abdomen where they are less numerous or absent; in median area becoming more numerous from metathorax to posterior end of abdomen; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. H): 47,3 (39,8 - 62,9) long; rigid; situated amongst the long setae and distributed in same pattern as the latter.

Spines (Fig. I and I^1): Bluntly pointed; 26,8 (22,9 - 32,8) long on anterior part of body; few spines occur in marginal areas of whole body; in median area occurring from the metathorax, becoming more numerous, more bluntly pointed, thick-

er and also shorter (17,1; 14,3 - 20,2) towards posterior end of abdomen; denser in median than in marginal area; absent in small area between median and marginal areas of abdomen.

Pores (Fig. J): Multilocular derm pores circular, 11,4 (9,5 - 12,6) in diameter; variation in diameter similar over entire body; with 14 - 20 microloculi in an outer circle, 4 - 8 macroloculi in inner circle and with a central loculus; absent on head, prothorax and mesothorax; in marginal and median areas occurring from metathorax becoming more numerous towards posterior end of abdomen; in median area more numerous than in marginal area.

Antennae (Fig. K): 8 segmented; 575,5 (356,5 - 778,0) long. Segment I twice as wide as long, with 2 - 6 short setae. Segment II half as long as segment III, with 2 - 8 long setae and 3 - 8 sensory pores in row near distal end. Segment III to VII all about of the same length but diminishing gradually in width; each with variable numbers of long, hairlike setae (48,7; 34,0 - 71,0) and short (18,5; 15,0 - 22,0) bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 3 - 4 long hairlike setae (59,7 ; 44,0 - 74,5), 3 to 4 shorter setae and 6 to 11 short fleshy setae (21,4 ; 19,5 - 25,0) placed apically.

Antennal segment	Length	Width
I	71,9 (59,8 - 80,0)	179,6 (154,8 - 214,3)
II	38,5 (32,4 - 43,8)	130,7 (106,0 - 150,0)
III	69,6 (55,7 - 89,3)	149,4 (131,2 - 166,7)
IV	73,8 (57,9 - 93,3)	125,2 (113,1 - 135,7)
V	65,9 (58,8 - 71,4)	109,8 (104,8 - 120,2)
VI	71,7 (62,9 - 81,0)	98,3 (85,7 - 107,1)
VII	76,0 (70,2 - 83,3)	95,4 (81,7 - 104,8)
VIII	95,5 (88,1 - 104,8)	71,7 (65,5 - 79,1)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 603,0 (457,4 - 731,5) long; and 586,3 (494,0 - 699,0) wide with numerous long setae (127,6 ; 82,0 - 160,0) on ventral side and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 6 - 14 long setae on posterior side and 7 - 19 on anterior side as well as 2 - 3 minute setae on posterior side and 1 - 3 on anterior side. Tarsus with 3 - 7 long setae on posterior side and 3 - 8 on anterior side as well as 1 - 4 dorsal pores grouped together proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Middle and hind legs (Fig. L): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 2 - 5 long setae on ventral side and numerous short setae on posterior and anterior sides. Trochanter with 2 - 5 long setae on ventral side; 1 - 5 minute setae, 1 - 4 long setae and 5 - 7 sensory pores on posterior side; 2 - 5

minute setae, 1 - 3 long setae and 5 - 7 sensory pores on anterior side. Femur 267,0 (207,4 - 329,6) long; 232,6 (141,0 - 338,0) wide, with long ventral setae (80,8 ; 55,0 - 128,0) and short, rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 147,2 (122,2 - 194,4) long; 110,5 (84,0 - 148,7) wide, with 4 - 9 long ventral setae (71,4 ; 46,0 - 116,1); 2 - 5 long setae and 3 - 9 minute setae on posterior side; 2 - 8 long setae and 0 - 4 minute setae on anterior side. Tarsus with 1 - 2 long ventral setae at distal end; 3 - 5 long setae on posterior side and 1 - 3 on anterior side; 3 - 5 dorsal pores grouped together proximally. Claw 134,6 (99,0 - 175,7) long; 17,9 (11,9 - 30,4) wide; slightly curved; smooth on inner surface; heavily sclerotized except basally; and with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with elongated openings; 3 - 5 small pores grouped together next to opening on posterior side. Atrium 103,1 (83,3 - 129,6) in diameter; with 3 - 10 large multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; 6 - 12 small simple pores in one or two inner circles.

Abdominal spiracles: Seven pairs; first two pairs half as small as thoracic spiracles; spiracles becoming smaller towards posterior part of abdomen; first pair situated more marginally. Atrium 59,9 (56,0 - 62,9) in diameter with 3 - 8 multilocular pores arranged in a circle on the peritreme wall just inwards to the atrium; 3 - 8 smaller simple pores in an inner circle.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips which are in some cases covered with short rigid setae.

Anal opening: Circular; sclerotized; situated sub-apically on the ventral surface in middle of small naked area.

MALE

Males were not seen and biological studies (par. 4) indicated that the species is parthenogenetic.

MATERIAL EXAMINED

South Africa, Malmesbury, 1898, at roots of vines, C.P. Lounsbury, collection no. 9 of C.K. Brain, type 1 female, paratype 1 female, uncertain material 2 females (USNM) and paratype 2 females, uncertain material 1 female (PPRI). Cape Colony, January, 1900, at roots of vine, C.P. Lounsbury, collection no. 77, topotype 1 female (USNM). In addition, the following material was studied. Malmesbury, February 1975, at roots of vines, C.A. de Klerk, collection no. MD 2, 6 females (OVRI); Malmesbury, November 1976, on roots of vines, C.A. de Klerk, collection no. MD 15, 10 cysts (OVRI); Malmesbury, March 1974, obtained in laboratory, C.A. de Klerk, collection no. MD 5, 5 larvae (OVRI).

PLATES AND LETTERING

Plate 4: Margarodes capensis (Giard), nymph of the cyst stage (with labium shown to one side)

Plate 5: Margarodes capensis (Giard), adult female

A	=	dorsal and ventral sides of body
B	=	dorsal long seta
C	=	dorsal short seta
D	=	dorsal long spine
E	=	dorsal multilocular derm pore
G	=	ventral long seta
H	=	ventral short seta
I	=	ventral long spine
I^1	=	ventral short spine
J	=	ventral multilocular derm pore
K	=	antenna
L	=	hind leg

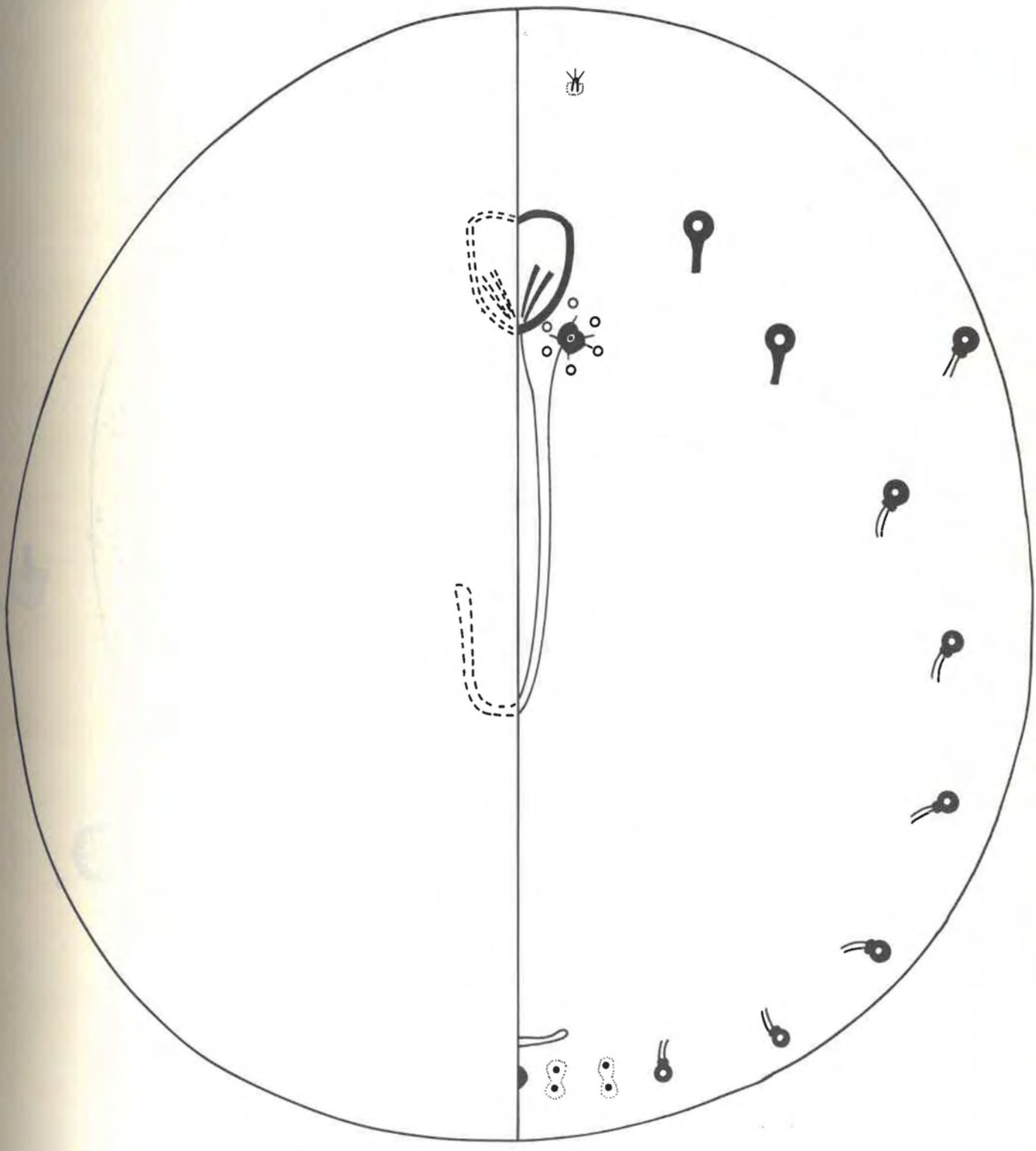

PLATE 4

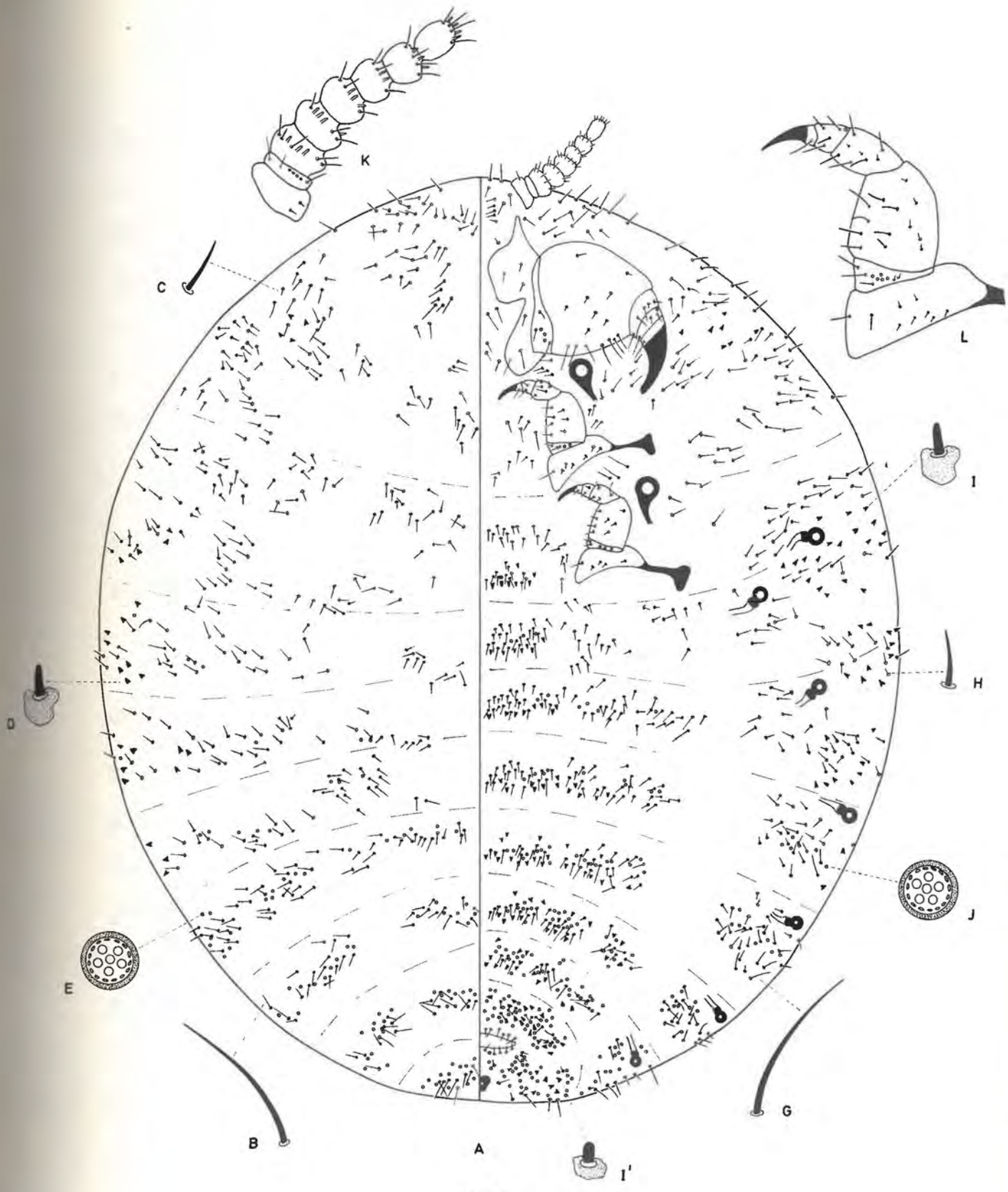

PLATE 5

MARGARODES GREENI BRAIN, 1915

Margarodes greeni Brain, 1915 : 187.
Coccionella greeni (Brain); Lindinger, 1954 : 615.
Promargarodes greeni (Brain); Jakubski, 1965 : 132.

This species was first described from material found at roots of vines at Elsenburg, Stellenbosch, collected by F.W. Pettey during October 1914. A number of cysts and four adult females were studied (Brain, 1915).

EGG, FIRST INSTAR LARVA AND MALE

These stages were not seen by the author and they have not been described in the literature.

NYMPH OF THE CYST STAGE (Plate 6)

GENERAL APPEARANCE

Spherical, varying in size to a maximum of 2,5 mm in diameter. Cyst wall thin but hard. Outer surface almost smooth (Fig. 26) with transverse lines on ventral side, giving the impression of segmentation (these lines are more perceptable after removing the outer layers); white to amber yellow in colour. A bright white colour underneath the outer layers.

DESCRIPTION

Antennae: Small rounded protrusion with 2 minute, bluntly pointed, fleshy setae at distal end.

Mouthparts: Sclerotized clypeo-labral complex situated opposite thoracic spiracles. Stylets forming a semi-circular loop; approximately two to three times as long as body

Fig. 26 : Cyst of Margarodes greeni Brain

when extended. Labium sclerotized; with 4 short setae.

Pores absent.

Thoracic spiracles: Two pairs with circular openings; 2 - 3 small pores grouped together next to opening on posterior side. Atrium 17,9 (15,2 - 23,8) in diameter with 4 - 10 multilocular pores.

Abdominal spiracles: Six pairs; first pair slightly smaller than thoracic spiracles and situated more marginally; the six pairs all about the same size. Atrium of first pair 14,8 (12,4 - 16,2) in diameter with 4 - 6 multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 2 - 3 cicatrices arranged in a line on each side of the anus. Cicatrices occur only between anus and last pair of abdominal spiracles.

Genital scar a transverse line situated anteriorly near anal opening.

ADULT FEMALE (Plate 7)

GENERAL APPEARANCE

Adult female small and white in colour. Segmentation clearly visible on both ventral and dorsal sides.

DESCRIPTION

Body (Fig. A) oval; 2,53 (2,24 - 3,04) mm long; 1,84 (1,68 - 2,16) mm wide; with distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 64,5 (59,5 - 67,6) long; distributed in low numbers over whole surface of dorsum; more numerous on head and on posterior part of abdomen; denser in marginal than in median area; grouped together on central line of each abdominal segment.

Short setae (Fig. C): 39,3 (35,2 - 44,0) long; rigid; situated amongst the long setae and distributed as the latter.

Spines (Fig. D): sharply pointed; 13,3 (9,5 - 15,7) long; occurring in very low numbers amongst setae in marginal area from metathorax, becoming less numerous but of the same size to posterior part of abdomen; absent in median area of whole dorsum.

Pores (Fig. E): Multilocular derm pores circular; 10,5

(9,5 - 11,9) in diameter; variation in diameter similar over entire body; with 8 to 13 microloculi in an outer circle, 3 to 6 macroloculi in an inner circle and with or without a central loculus; dispersed irregularly on head, thorax and abdomen in marginal and median areas.

VENTRAL SURFACE

Long setae (Fig. F): 63,7 (52,9 - 72,6) long; more numerous than on dorsum except for narrow area between median and marginal areas of abdomen where they are absent; in median area becoming more numerous towards posterior end of abdomen; grouped together on central line of each abdominal segment.

Short setae (Fig. G): 35,1 (32,9 - 36,7) long; rigid; situated amongst the long setae and distributed in same pattern as the latter.

Spines (Fig. H and H^1): Sharply pointed; 12,1 (10,7 - 12,9) long; occurring in very low numbers amongst setae in marginal area from metathorax, becoming less numerous towards posterior end of abdomen; in median area they occur from metathorax, becoming more numerous, more bluntly pointed and thicker but of the same length towards posterior end of abdomen; more numerous in median than in marginal area; absent in small area between median and marginal areas of abdomen.

Pores (Fig. I): Multilocular derm pores circular; 10,5 (9,5 - 11,9) in diameter; variation in diameter similar over entire body; with 8 to 13 microloculi in an outer circle, 3 to 6 macroloculi in an inner circle and with or

without a central loculus; dispersed irregularly on head, thorax and abdomen in marginal and median areas.

Antennae (Fig. J): 8 segmented; 424,7 (361,1 - 491,7) long. Segment I twice as wide as long, with 1 - 2 short rigid setae as well as 6 - 7 minute setae in row at proximal end. Segment II as long as segment III, with 3 - 5 rigid setae and 7 sensory pores in row near distal end. Segment III - VII all about the same length but diminishing gradually in width; each with variable numbers of long setae (42,7 ; 40,2 - 47,1) and short (26,7 ; 23,8 - 29,0) bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 6 - 10 long setae (55,8 ; 52,3 - 59,5) and 6 - 8 short fleshy setae (30,5 ; 29,8 - 34,8) placed apically.

Antennal segment	Length	Width
I	79,3 (71,4 - 87,1)	127,7 (95,2 - 159,5)
II	32,7 (27,6 - 39,3)	75,7 (69,3 - 84,0)
III	39,0 (31,2 - 46,4)	86,2 (75,7 - 99,0)
IV	47,4 (41,7 - 55,0)	72,4 (68,8 - 79,0)
V	51,3 (41,4 - 63,6)	63,4 (57,6 - 69,8)
VI	51,5 (47,6 - 57,4)	59,3 (56,0 - 63,3)
VII	57,8 (52,6 - 66,2)	55,5 (52,4 - 58,1)
VIII	74,4 (69,3 - 80,7)	47,3 (43,6 - 50,7)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 274,7 (260,2 - 302,8) long; 265,2 (225,0 - 331,5) wide with numerous long setae (99,0 ; 95,2 - 106,7) on ventral side and short, rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 6 - 7

long setae on posterior side and 7 - 10 on anterior side as well as one minute seta on each of posterior and anterior sides. Tarsus with 4 - 5 long setae on posterior side and 3 on anterior side as well as 3 dorsal pores proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Middle and hind legs (Fig. K): Both pairs similar in size and shape. Coxa twice as wide as long, with sclerotized apodeme; 3 - 5 long setae on ventral side and 5 - 9 short setae on both of posterior and anterior sides. Trochanter with 2 long setae on ventral side; 0 - 2 minute setae and 5 sensory pores on posterior side; 2 - 3 minute setae and 5 sensory pores on anterior side. Femur 168,7 (150,0 - 182,9) long; 105,9 (91,2 - 131,4) wide with long ventral setae (84,2 ; 77,9 - 93,8) and short, rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 112,4 (103,3 - 128,6) long; 43,9 (42,4 - 46,7) wide with 2 long ventral setae (51,5 ; 43,6 - 62,9); with 5 - 6 long setae and one minute seta on each of posterior and anterior sides. Tarsus with 2 long ventral setae at distal end; 3 - 4 long setae on posterior side and 2 on anterior side; 4 dorsal pores grouped together proximally. Claw 77,2 (72,0 - 85,0) long; 16,1 (14,3 - 17,4) wide; slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 3 - 4 small pores grouped together next to opening on posterior

side. Atrium 45,8 (43,8 - 47,6) in diameter; with 3 - 5 multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; 6 simple pores in an inner circle.

Abdominal spiracles: Six pairs; slightly smaller than thoracic spiracles and the 6 pairs are all about the same size; first pair situated more marginally. Atrium 29,1 (28,6 - 34,8) in diameter; with 5 - 6 multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; simple pores absent.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening a transverse fissure situated anteriorly near anus with distinct lips, covered with short, rigid setae.

Anal opening circular; sclerotized; situated sub-apically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Elsenburg, October 1914, at roots of vines, C.K. Brain, collection no. 10a, type 1 female, paratype 1 female (USNM) and paratype 1 female (PPRI). In addition to the type-series the following material was studied. Groot Drakenstein, November 1975, on roots of kikuju grass, C.A. de Klerk, collection no. MD 14, 5 cysts (OVRI).

PLATES AND LETTERING

Plate 6: Margarodes greeni Brain, nymph of the cyst stage (with labium shown to one side)

Plate 7: Margarodes greeni Brain, adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal short seta

D = dorsal sharply pointed spine

E = dorsal multilocular derm pore

F = ventral long seta

G = ventral short seta

H = ventral sharply pointed spine

H^1 = ventral bluntly pointed spine

I = ventral multilocular derm pore

J = antenna

K = hind leg.

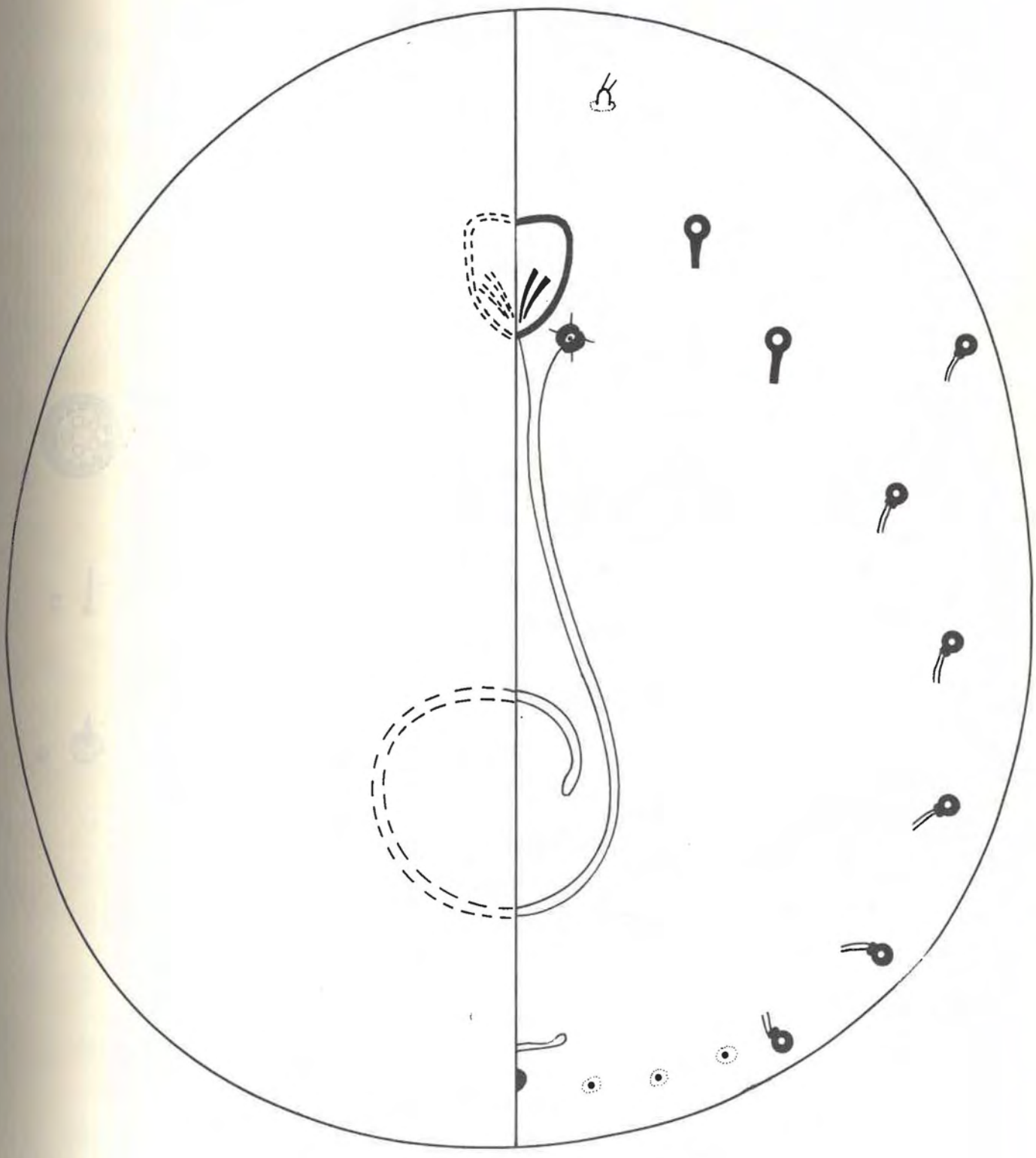

PLATE 6

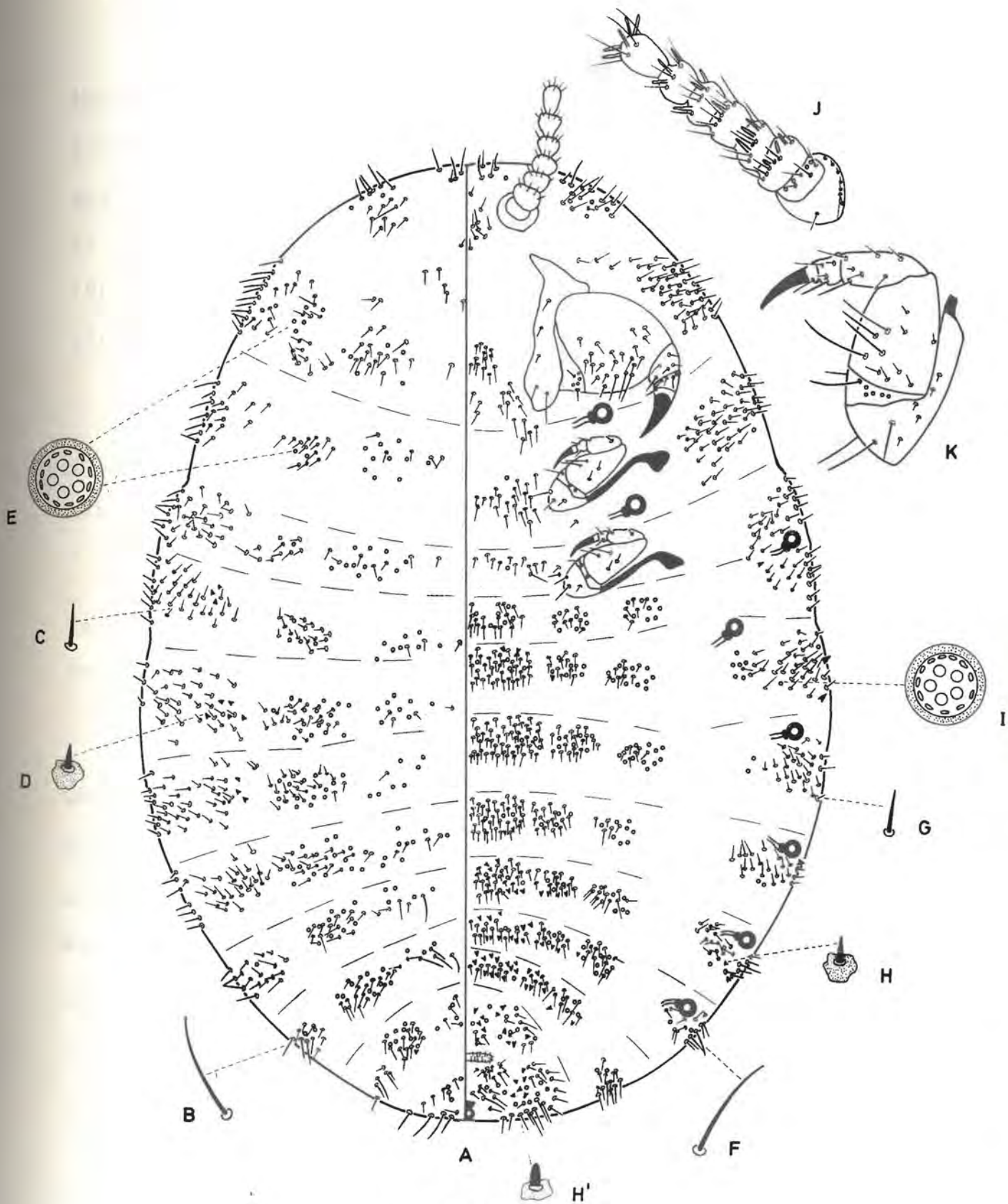

PLATE 7

MARGARODES NEWSTEADI BRAIN, 1915

Margarodes newsteadi Brain, 1915 : 187

Promargarodes newsteadi (Brain); Jakubski, 1965 : 137

This species was first described from material found at roots of grass in Pretoria, collected by C.K. Brain during October 1914. A number of cysts and two adult females were studied (Brain, 1915).

EGG, FIRST INSTAR LARVA AND MALE

These stages have not been described in previous publications nor have they been observed by the author.

NYMPH OF THE CYST STAGE

"Almost spherical, about 2,5 mm in diameter, creamy yellow in colour" (Brain, 1915). Not seen by the author.

ADULT FEMALE (Plate 8)

GENERAL APPEARANCE

"Slightly longer and broader than M. peringueyi, which it resembles very closely" (Brain, 1915). Live specimens not seen by the author.

DESCRIPTION

Body (Fig. A) oval; 2,64 (2,56 - 2,72) mm long; 2,76 (2,48 - 3,04) mm wide; with distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 80,6 (78,8 - 82,4) long; distributed over

whole dorsum but denser in marginal than median area; distributed over whole surface of each abdominal segment.

Short setae (Fig. C): 36,4 (34,5 - 38,3) long; situated amongst the long setae and distributed as the latter.

Spines (Fig. D and D^1): Bluntly pointed, 23,8 long on anterior part of body, occurring densely in marginal areas of thorax becoming less numerous, more bluntly pointed and also shorter (15,5 ; 14,3 - 16,7) towards posterior end of abdomen; few spines occur in median area of thorax becoming more numerous towards posterior end of abdomen.

Pores (Fig. E): Multilocular derm pores circular, 13,8 (13,1 - 14,3) in diameter; variation in diameter similar over entire body; with 12 - 15 microloculi in an outer circle, 3 - 6 macroloculi in inner circle and with a central loculus; dispersed irregularly on head, thorax and abdomen; becoming more numerous towards posterior end of abdomen; density the same in marginal as in median area.

VENTRAL SURFACE

Long setae (Fig. F): 78,7 (71,4 - 86,0) long; more numerous than on dorsum; density the same over whole body except for narrow area between median and marginal areas of abdomen where they are less numerous or absent; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. G): 37,8 (37,6 - 37,9) long; situated amongst the long setae and distributed in same pattern as the latter.

Spines (Fig. H and H^1): Bluntly pointed 26,6 (26,4 - 26,7) long on anterior part of body, occurring densely in marginal

area of thorax becoming less numerous, more bluntly pointed and also shorter (12,7 ; 12,1 - 13,3) towards posterior end of abdomen; in median area occurring from mesothorax, becoming more numerous and also more bluntly pointed and shorter towards posterior end of abdomen; absent or in low numbers in narrow area between median and marginal areas of abdomen.

Pores (Fig. I): Multilocular derm pores circular, 13,8 (13,1 - 14,3) in diameter; variation in diameter similar over entire body; with 12 - 15 microloculi in an outer circle, 3 - 6 macroloculi in inner circle and with a central loculus; dispersed irregularly on head, thorax and abdomen; becoming more numerous towards posterior end of abdomen; density the same in marginal as in median area.

Antennae (Fig. J): 8 segmented; 439,4 (431,5 - 447,2) long. Segment I twice as wide as long, with 2 long setae as well as 8 minute setae placed in a row at the base. Segment II half as long as segment III, with 3 long setae and with inconspicuous sensory pores at distal end. Segments III to VII all of about the same length but diminishing gradually in width; with variable numbers of long, hairlike setae (48,8 ; 47,6 - 50,0) and short (17,6), bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 5 - 7 long hairlike setae (64,3 ; 63,1 - 65,5) and 10 - 11 short fleshy setae (31,2 ; 30,9 - 31,4) placed apically.

Antennal segment	Length	Width
I	102,8 (88,6 - 117,1)	182,7 (152,4 - 212,9)
II	23,1 (20,7 - 25,5)	137,9 (135,0 - 140,7)
III	52,8 (52,6 - 52,9)	151,2 (151,0 - 151,4)
IV	61,8 (59,3 - 64,3)	127,2 (125,5 - 128,8)
V	61,3 (53,3 - 69,3)	110,8 (107,9 - 113,6)
VI	56,4 (48,3 - 64,5)	102,1 (99,8 - 104,3)
VII	57,5 (54,8 - 60,2)	90,1 (86,2 - 94,0)
VIII	82,2 (77,4 - 87,0)	62,9 (60,5 - 65,2)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 363,0 (324,1 - 401,9) long; 362,0 (358,3 - 365,7) wide with long setae (110,6 ; 109,0 - 112,1) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 5 - 6 long setae on posterior side and 4 on anterior side as well as one minute seta on both posterior and anterior sides. Tarsus with 3 long setae on posterior side and 3 - 4 on anterior side as well as 4 dorsal pores grouped together proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long ventral seta on each of posterior and anterior sides.

Middle and hind legs (Fig. K): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 2 to 3 long setae on ventral side and 12 setae on each of posterior and anterior sides. Trochanter with 3 to 4 long setae on ventral side; 1 to 2 minute setae, 2 long setae and 6 sensory pores on posterior side; 1 to 2 minute setae, 0 to 1 long seta and 6 to 7 sensory pores on anterior side. Femur 195,5

(187,6 - 203,3) long; 192,2 (186,4 - 198,0) wide with long ventral setae (84,1 ; 77,6 - 90,5) and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 119,7 (112,4 - 127,0) long; 83,6 (77,0 - 90,2) wide with 2 long ventral setae (60,8 ; 60,5 - 61,0) at distal end; 3 long setae and 1 minute seta on each of posterior and anterior sides. Tarsus with one long ventral seta at distal end; 2 to 3 long setae on each of posterior and anterior sides; 4 dorsal pores grouped proximally. Claw 162,7 (162,0 - 163,3) long; 17,2 (16,2 - 18,1) wide; slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 2 small pores grouped together next to opening on posterior side. Atrium 63,5 (61,9 - 65,0) in diameter; with 2 to 3 large multilocular pores arranged in an outer circle on the peritreme wall, just inwards to the atrium; 5 to 7 simple pores in an inner circle.

Abdominal spiracles: Six pairs; three times smaller than thoracic spiracles; all about of the same size; first pair situated more marginally. Atrium 19,6 (16,9 - 22,4) in diameter with 4 multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; simple pores absent.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips, covered with short rigid setae.

Anal opening: Circular or oval; sclerotized; situated subapically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Pretoria, October 1914, at roots of grass, C.K. Brain, collection no. YC 10, type 1 female, paratype 1 female (USNM).

PLATE AND LETTERING

Plate 8: *Margarodes newsteadi* Brain, adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal short seta

D = dorsal long spine

D^1 = dorsal short spine

E = dorsal multilocular derm pore

F = ventral long seta

G = ventral short seta

H = ventral long spine

H^1 = ventral short spine

I = ventral multilocular derm pore

J = antenna

K = hind leg

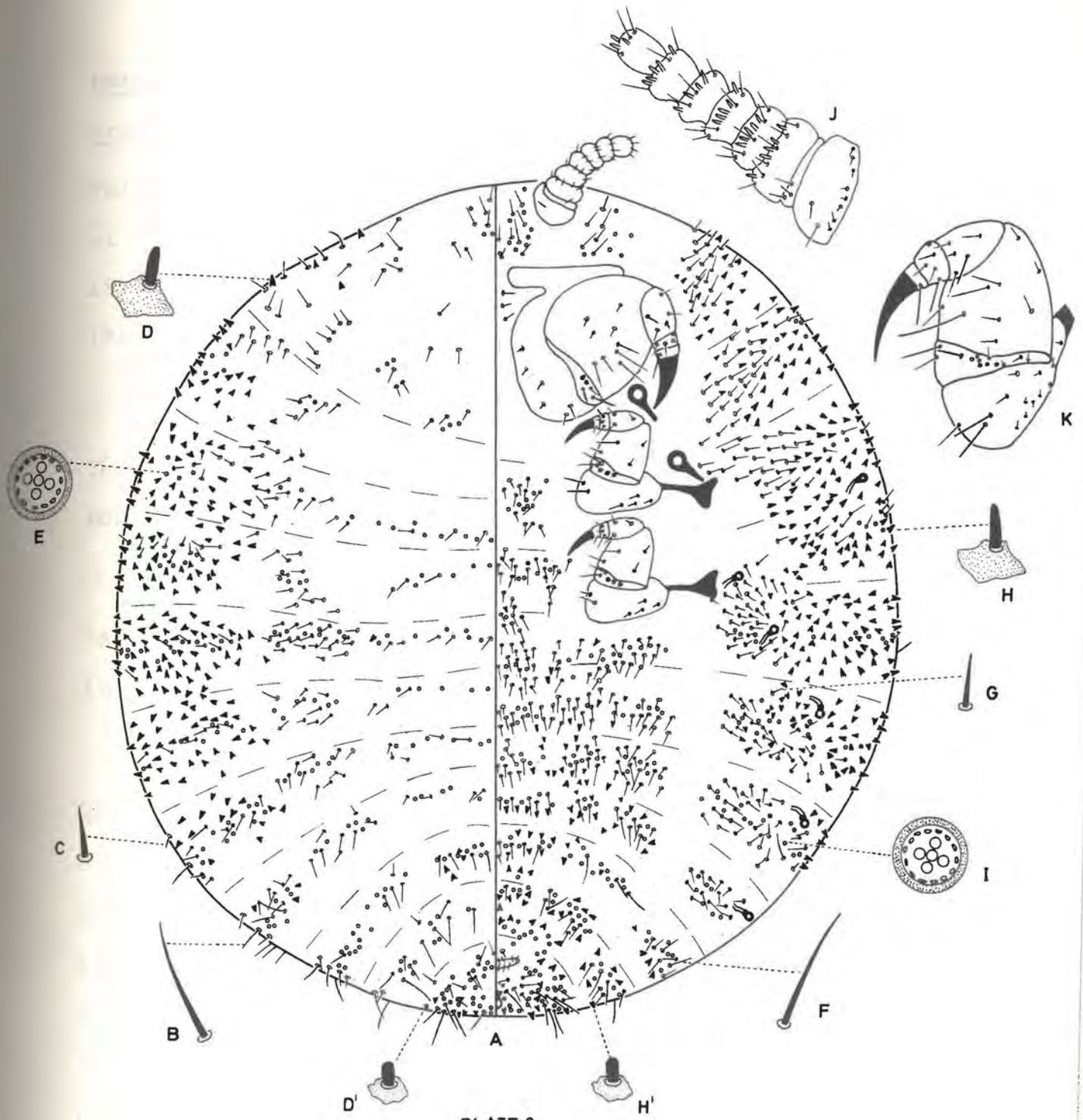

PLATE 8

MARGARODES PERINGUEYI BRAIN, 1915

Margarodes peringueyi Brain, 1915 : 188

Promargarodes peringueyi (Brain); Jakubski, 1965 : 134

This species was first described from material found at roots of grass in Pretoria, collected by C.K. Brain during October 1914. A number of cysts and four adult females were studied (Brain, 1915).

EGG, FIRST INSTAR LARVA AND MALE

These stages have not been described in previous publications nor have they been observed by the author.

NYMPH OF THE CYST STAGE

"Almost spherical, about 2 to 2,5 mm in diameter, milky-white in colour, translucent" (Brain, 1915). Not seen by the author.

ADULT FEMALE (Plate 9)

GENERAL APPEARANCE

"2,5 to 3 mm long when extended, creamy white to pale yellow in colour with a median dorsal region which sinks below the lateral areas and through which the darker body contents are visible. Segmentation plainly visible" (Brain, 1915). Live specimens not seen by the author.

DESCRIPTION

Body (Fig. A) oval; 3,10 (2,64 - 3,60) mm long; 2,48 (2,00 - 2,88) mm wide; with distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 89,2 (71,4 - 120,7) long; evenly distributed over whole body in marginal and median areas; distributed over whole surface of each abdominal segment.

Short setae (Fig. C): 47,2 (32,4 - 56,9) long; situated amongst the long setae and distributed as the latter.

Spines (Fig. D and D^1): Sharply pointed; 27,4 (23,8 - 29,5) long on anterior part of body, occurring densely in marginal area of thorax becoming less numerous towards posterior end of abdomen but of the same size; absent or in low numbers in median areas of whole body.

Pores (Fig. E): Multilocular derm pores circular, 10,4 (9,5 - 11,9) in diameter; with variation in diameter similar over entire body; with about 13 microloculi in an outer circle and 6 to 8 macroloculi in inner circle and without a central loculus; occurring in very low numbers on meso- and metathorax as well as on first abdominal segments; becoming more numerous towards posterior end of abdomen in marginal area; denser in marginal area than in median areas.

VENTRAL SURFACE

Long setae (Fig. F): 100,3 (81,9 - 120,2) long, density the same over whole body except for narrow area between median and marginal areas of abdomen where they are less numerous or absent; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. G): 37,7 (27,1 - 47,6) long; situated amongst the long setae and distributed in same pattern as the latter.

Spines (Fig. H and H^1): Sharply pointed; 27,7 (23,8 - 35,2) long on anterior part of body, occurring densely in marginal area of thorax, becoming less numerous towards posterior end of abdomen but of the same length; in median area occurring from metathorax, becoming more numerous, more bluntly pointed and shorter (17,8 ; 15,5 - 23,8) towards posterior end of abdomen; less numerous or absent in narrow area between median and marginal areas of abdomen.

Pores (Fig. I): Multilocular derm pores circular, 10,4 (9,5 - 11,9) in diameter; with variation in diameter similar over entire body; with about 13 microloculi in an outer circle and 6 to 8 macroloculi in an inner circle without a central loculus; absent on head and in marginal area of thorax, in marginal areas of abdomen occurring in very low numbers, becoming more numerous towards posterior end of abdomen; in median area they occur from the metathorax, becoming more numerous towards posterior end of abdomen; more numerous in median than in marginal areas.

Antennae (Fig. J): 8 segmented; 442,1 (420,4 - 469,4) long; segment I twice as wide as long, with 0 to 1 long seta as well as 3 to 5 minute setae placed in a row at the base. Segment II approximately of the same length as segment III, with 2 to 3 long setae, 5 to 6 minute setae placed in a row and without sensory pores. Segments III to VII all of about the same length, but diminishing gradually in width; each with variable numbers of long hairlike setae (58,9 ; 51,7 - 68,3) and short (25,4 ; 23,8 - 26,7) bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with

4 to 8 long hairlike setae (51,0 ; 39,0 - 69,0) and 9 to 14 short fleshy setae (31,1 ; 26,2 - 35,7) placed apically.

Antennal segment	Length	Width
I	70,1 (59,5 - 83,3)	143,0 (102,4 - 189,3)
II	35,5 (31,4 - 40,5)	102,4 (83,3 - 120,2)
III	41,6 (32,4 - 51,0)	109,2 (90,7 - 126,4)
IV	53,3 (39,5 - 67,1)	99,5 (82,6 - 115,5)
V	61,6 (52,6 - 65,0)	92,2 (83,8 - 105,2)
VI	58,2 (50,2 - 66,0)	83,5 (74,5 - 91,7)
VII	62,2 (60,7 - 65,0)	73,9 (66,2 - 80,2)
VIII	84,9 (74,5 - 95,2)	61,6 (53,8 - 66,7)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 382,0 (370,4 - 393,5) long; 369,4 (325,9 - 407,4) wide with long setae (128,3 ; 123,3 - 132,9) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 6 to 7 long setae and 1 to 2 minute setae on posterior side as well as on anterior side. Tarsus with 4 to 5 long setae on posterior side and 3 to 4 on anterior side as well as 4 dorsal pores grouped together proximally . Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Middle and hind legs (Fig. K): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 2 to 3 long setae on ventral side and 5 to 8 short setae on posterior side as well as on anterior side. Trochanter with 3 long setae on ventral side; one minute seta and 3 sensory pores on posterior side; 2 to 3 minute setae;

0 to 1 long seta and 3 sensory pores on anterior side. Femur 179,2 (157,1 - 201,9) long; 135,6 (108,8 - 157,1) wide with long ventral setae (85,8 ; 58,3 - 95,2) and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 114,9 (95,2 - 130,7) long; 74,0 (62,9 - 91,7) wide with 2 long ventral setae (66,4 ; 57,4 - 77,6) at distal end; 2 to 3 long setae and 1 to 2 minute setae on posterior side; 2 to 4 long setae and 1 minute seta on anterior side. Tarsus with 2 long ventral setae at distal end; 2 to 3 long setae on each of posterior and anterior sides; 3 to 4 dorsal pores grouped proximally. Claw 80,2 (71,0 - 99,8) long; 7,5 (4,8 - 10,5) wide; strongly curved; serrated on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 0 to 1 short seta and 3 to 4 small pores grouped together next to opening on posterior side. Atrium 67,4 (63,1 - 74,8) in diameter; with 4 to 5 large multilocular pores arranged in an outer circle on the peritreme wall, just inwards to the atrium; 3 to 4 simple pores in an inner circle.

Abdominal spiracles: Six pairs; first two pairs half as small as thoracic spiracles; spiracles becoming slightly smaller towards posterior end of abdomen; first pair situated more marginally. Atrium of first two pairs of spiracles 32,4 (26,9 - 38,6) in diameter; with 3 to 7 multilocular pores arranged in a circle on the peritreme wall just inwards to the atrium; 0 to 3 simple pores in an inner circle.

Mouthparts: True mouthparts absent. Folds occur in the body

at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips covered with short rigid setae or without such setae.

Anal opening: Circular or oval; sclerotized; situated subapically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Pretoria, October 1914, at roots of grass, C.K. Brain, collection no. 10, type 1 female, paratype 2 females (USNM) and paratype 2 females (PPRI).

PLATE AND LETTERING

Plate 9: *Margarodes peringueyi* Brain, adult female

A	=	dorsal and ventral sides of body
B	=	dorsal long seta
C	=	dorsal short seta
D	=	dorsal long spine on anterior part of body
D^1	=	dorsal long spine on posterior end of body
E	=	dorsal multilocular derm pore
F	=	ventral long seta
G	=	ventral short seta
H	=	ventral long spine
H^1	=	ventral short spine
I	=	ventral multilocular derm pore
J	=	antenna
K	=	hind leg

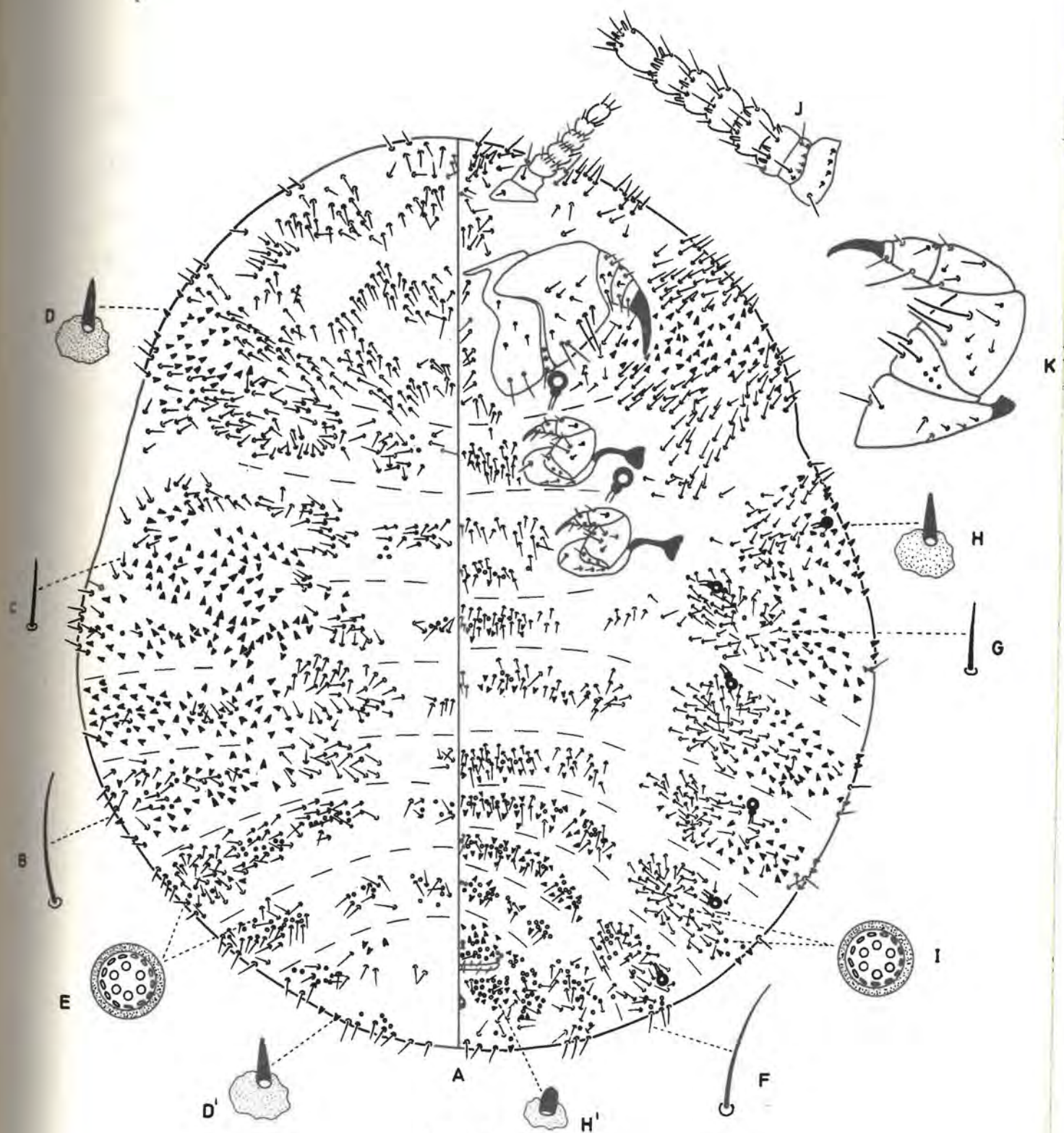

PLATE 9

MARGARODES PILOSUS (JAKUBSKI) 1965

Neomargarodes pilosus Jakubski, 1965 : 79

This species was collected by C.P. Lounsbury during May 1917 at Paardeberg in the Orange Free State and described from one adult female (slide no. 39 - 2845 of the U.S. Dept. of Agriculture). As no other material except this slide was available for this study and as a detailed description was given by Jakubski (1965), this species was not redescribed.

MARGARODES PRIESKAENSIS (JAKUBSKI) 1965

Sphaeraspis prieskaensis Jakubski, 1965 : 120

This species was first described from material found at roots of vines in Kakamas and Prieska during 1946, 1953 and 1958. Eleven adult females were studied (Jakubski, 1965).

MALE

GENERAL APPEARANCE

According to Du Toit (1975) the winged adult male has no mouthparts and does not feed. A detailed description is given by Theron (1958) under the species name of M. vitium. Not seen by the author.

EGG AND FIRST INSTAR LARVA

These stages have not been described in previous publications nor have they been observed by the author.

NYMPH OF THE CYST STAGE (Plate 10)

GENERAL APPEARANCE

Almost spherical, varying in size to a maximum of 6,0 mm in diameter. Cyst wall thick and very hard. Outer surface rough and gives the impression of that of a tortoise shell (Fig. 27); amber yellow in colour.

DESCRIPTION

Antennae: Small rounded protrusion in deep pit with minute, bluntly pointed, fleshy setae at distal end.

Mouthparts: Sclerotized clypeo-labral complex situated opposite thoracic spiracles. Stylets forming an oblong loop;

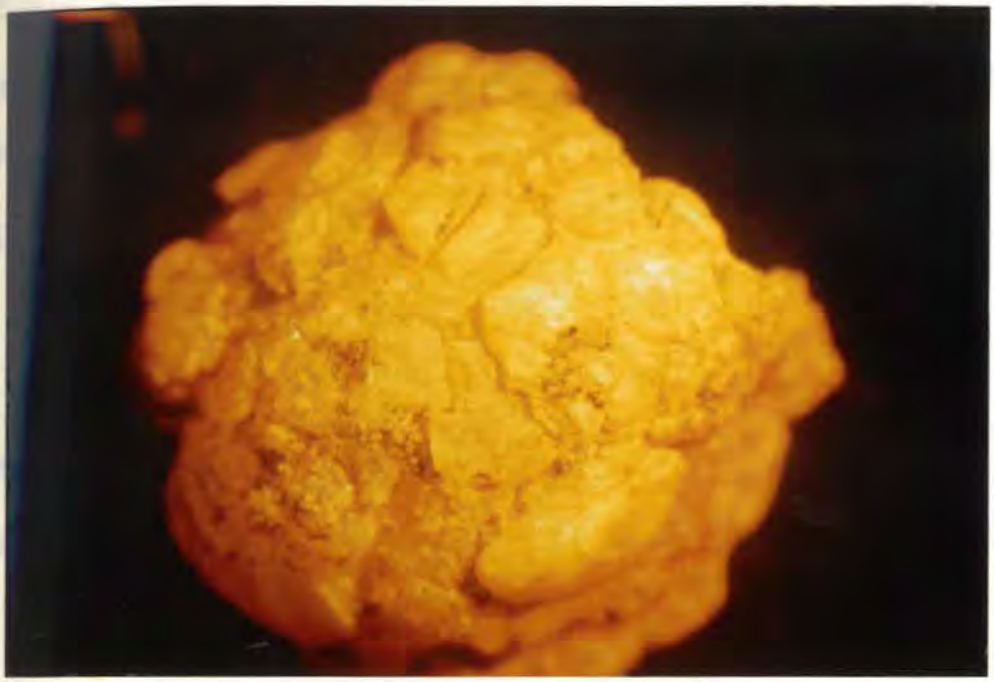

Fig. 27 : Cyst of Margarodes prieskaensis (Jakubski)

approximately as long as body when extended. Labium sclerotized; with about 10 short setae.

Pores: 7 to 29 multilocular derm pores situated around labium; each with numerous microloculi in an outer circle and 3 to 4 macroloculi in the centre.

Thoracic spiracles: Two pairs with circular openings; 2 to 4 small pores grouped together next to opening on posterior side. Atrium 65,0 (35,2 - 139,8) in diameter with about 20 multilocular pores.

Abdominal spiracles: Seven pairs; first pair approximately the same size as thoracic spiracles and situated more marginally; becoming smaller towards posterior end of abdomen. Atrium of first pair 60,4 (32,4 - 137,0) in diameter with 8

multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 3 to 7 cicatrices arranged in a line on each side of anus. Cicatrices occur between anus and fifth pair of abdominal spiracles.

Genital scar a transverse line situated anteriorly near anal opening.

ADULT FEMALE (Plate 11)

GENERAL APPEARANCE

The adult female varies greatly in size, yellow in colour with dark brown claws. Body densely covered with long hair-like setae. Segmentation plainly visible on both ventral and dorsal sides.

DESCRIPTION

Body (Fig. A) oval, 7,87 (5,00 - 11,72) mm long; 5,68 (3,75 - 8,13) mm wide with distinct segmentation on dorsal and ventral sides of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 361,9 (319,4 - 412,0) long; thin and hairlike; numerous, distributed on whole dorsum in marginal and median areas; distributed over whole surface of each abdominal segment.

Short setae absent.

Spines (Fig. C and C^1): Club-shaped; 35,4 (27,4 - 47,6) long on anterior part of body; occurring in marginal area from mesothorax, becoming more numerous, slightly shorter (30,8 ;

25,0 - 47,6) and bulbous in form towards posterior end of abdomen; occurring in median area only in bulbous form and on last 2 to 4 abdominal segments.

Pores (Fig. D): Multilocular derm pores circular, 13,8 (12,1 - 16,2) in diameter; variation in diameter similar over entire body; with 10 to 18 microloculi in an outer circle, 8 to 11 macroloculi in inner circle with 1 to 3 loculi in the centre; dispersed in low density only from metathorax, their numbers becoming more numerous towards posterior end of abdomen; density in median and marginal areas the same.

VENTRAL SURFACE

Long setae (Fig. E): 349,5 (287,0 - 384,3) long; thin and hairlike; all areas of body as densely covered as dorsum; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. F): 98,0 (69,4 - 129,6) long; occurring in low numbers amongst the long setae in marginal areas of whole ventral surface; more numerous in median area of abdomen.

Spines (Fig. G and G^1): Club-shaped; 39,0 (31,0 - 47,6) long on anterior part of body; occurring in marginal areas from mesothorax, becoming more numerous, slightly shorter (27,6 ; 23,8 - 35,7) and bulbous in form towards posterior end of abdomen; occurring in median area from metathorax, becoming more numerous, bulbous in form but of the same length (47,2 ; 34,5 - 61,9) towards posterior end of abdomen.

Pores (Fig. H): Multilocular derm pores circular, 13,8 (12,1 - 16,2) in diameter; variation in diameter similar over

entire body; with 10 to 18 microloculi in an outer circle, 8 to 11 macroloculi in inner circle with 1 to 3 loculi in the centre; dispersed in low density only from metathorax, their numbers becoming more numerous towards posterior end of abdomen; density in median and marginal areas the same.

Antennae (Fig. I): 8 segmented; 669,5 (486,1 - 893,5) long. Segment I twice as wide as long, with 4 to 5 minute setae placed in a row at the base. Segment II half as long as segment III, with 3 to 6 long setae and 1 to 2 sensory pores at distal end. Segment III to VII all of about the same length but diminishing gradually in width; each with variable numbers of long hairlike setae (87,7 ; 71,4 - 104,8) and short (26,9 ; 23,8 - 31,0) bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 5 to 6 long hairlike setae (84,0 ; 71,4 - 110,7), 4 to 9 shorter setae and 7 to 12 short, fleshy setae (27,3 ; 23,8 - 33,8) placed apically.

Antennal segment	Length	Width
I	94,2 (57,4 - 134,3)	215,3 (148,2 - 277,8)
II	38,5 (27,8 - 46,3)	165,4 (134,3 - 185,2)
III	76,5 (64,8 - 92,6)	191,7 (150,0 - 222,2)
IV	86,1 (60,2 - 115,7)	179,4 (150,0 - 208,3)
V	85,2 (55,6 - 111,1)	148,9 (131,5 - 168,5)
VI	87,2 (55,6 - 115,7)	132,8 (115,7 - 150,0)
VII	90,0 (55,6 - 122,2)	115,7 (92,6 - 134,3)
VIII	115,4 (92,6 - 152,8)	99,6 (92,6 - 111,1)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter also with long and short setae as well as sensory pores. Femur 762,1 (555,6 - 1080,3) long; 693,2 (472,2 - 918,2) wide

with numerous long setae (196,3 ; 166,7 - 236,1) on ventral side and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 15 to 25 long setae on each of posterior and anterior sides. Tarsus with 5 to 10 long setae on each of posterior and anterior sides as well as 4 dorsal pores grouped together proximally. Claw slightly curved, smooth on inner surface; heavily sclerotized except basally with one long seta-like digitule on each of posterior and anterior sides.

Middle and hind legs (Fig. K): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 7 to 13 long setae on ventral side; posterior side with 6 to 16 long and short setae; anterior side with 10 to 14 long and short setae. Trochanter with 2 to 5 long setae on ventral side; 3 to 5 minute setae, 2 to 4 long setae and 7 to 16 sensory pores on posterior side; 3 to 4 minute setae; 2 to 3 long setae and 4 to 8 sensory pores on anterior side. Femur 317,3 (203,7 - 463,0) long; 305,3 (203,7 - 455,6) wide with long ventral setae (183,3 ; 142,9 - 233,3) and short rigid setae on posterior and anterior sides. Tibia 210,3 (143,5 - 277,8) long; 154,9 (108,8 - 203,7) wide with 5 to 6 long ventral setae (155,6 ; 119,1 - 199,1); 5 to 20 long setae and 6 to 10 minute setae on posterior side; 11 to 18 long setae and 3 to 5 minute setae on anterior side. Tarsus with 2 long ventral setae; 3 to 5 long setae on each of posterior and anterior sides; 3 to 6 dorsal pores grouped together proximally. Claw 291,5 (175,0 - 425,9) long; 38,4 (23,8 - 60,2) wide; almost straight, smooth on inner surface; heavily sclerotized except basally; with one long seta-like

digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs of thoracic spiracles with circular or elongated openings; 3 to 5 small pores next to opening on posterior side. Atrium 104,5 (86,1 - 133,3) in diameter; with 8 to 11 large multilocular pores arranged in one or two circles on the peritreme wall just inwards to the atrium; 8 to 20 simple pores.

Abdominal spiracles: Seven pairs; first 2 pairs slightly smaller than thoracic spiracles; spiracles diminishing slightly in size towards posterior part of abdomen; first pair situated more marginally. Atrium of first two pairs 83,2 (55,6 - 92,6) in diameter; with about 10 multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; 8 to 10 small simple pores.

Mouthparts: True mouthparts absent. Folds occur in body at the place where mouthparts occur in other stages.

Genital opening a transverse fissure situated anteriorly near anus with indistinct lips, with or without setae.

Anal opening: Circular or oval; sclerotized; situated apically or sub-apically on the ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Upington, August 1977, at roots of vines, A. Calitz, collection no. MD 20 of C.A. de Klerk, 6 adult females and 5 cysts (OVRI). These specimens came from the same general area and host plant as the holotype and agree well with the original description of Jakubski (1965).

PLATES AND LETTERING

Plate 10: *Margarodes prieskaensis* (Jakubski), nymph of the cyst stage (with labium shown to one side).

Plate 11: *Margarodes prieskaensis* (Jakubski) adult female

A = dorsal and ventral sides of body
B = dorsal long seta
C = dorsal long spine
C^1 = dorsal bulbous spine
D = dorsal multilocular derm pore
E = ventral long seta
F = ventral short seta
G = ventral long spine
G^1 = ventral bulbous spine
H = ventral multilocular derm pore
I = antenna
K = hind leg

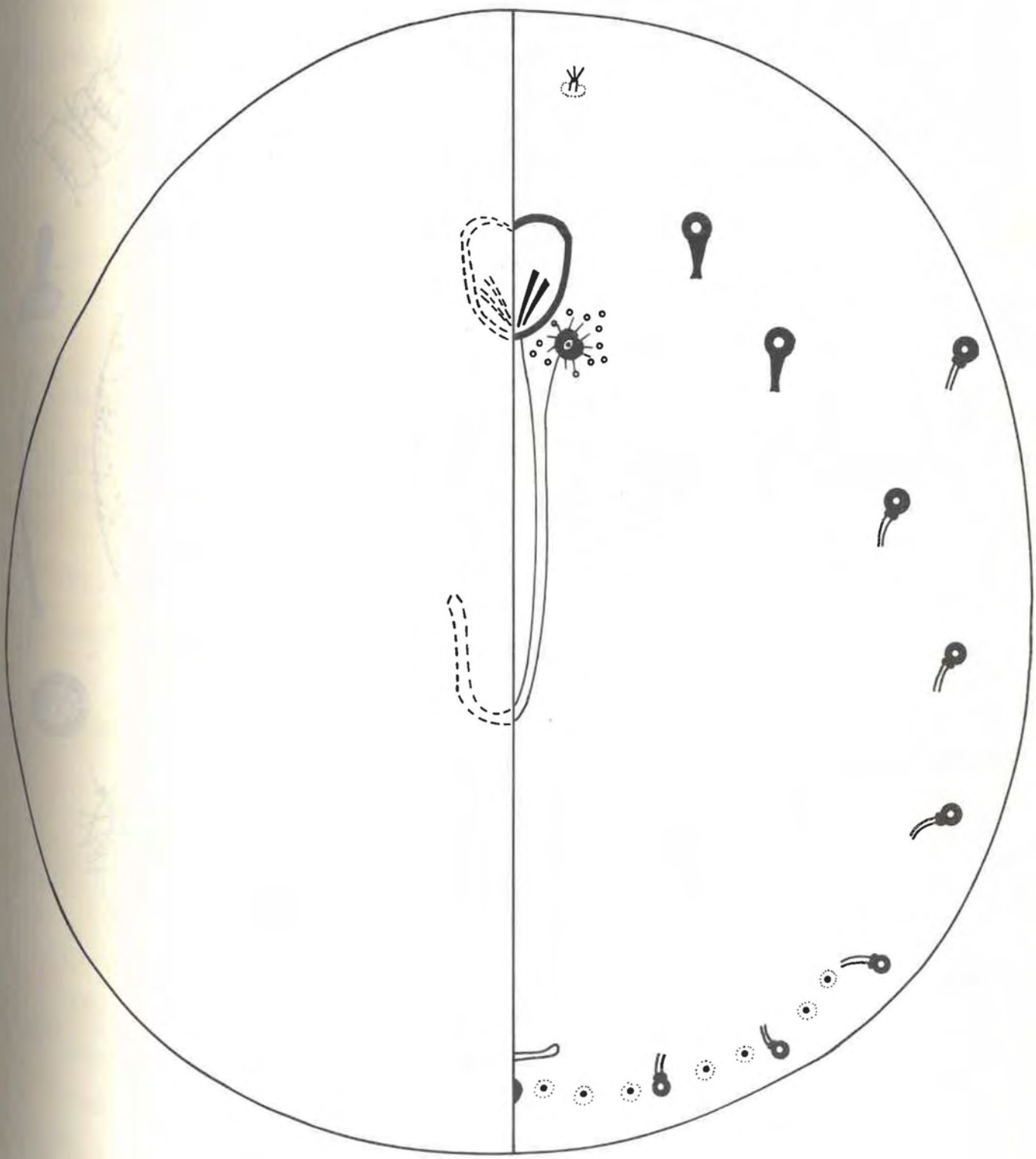

PLATE 10

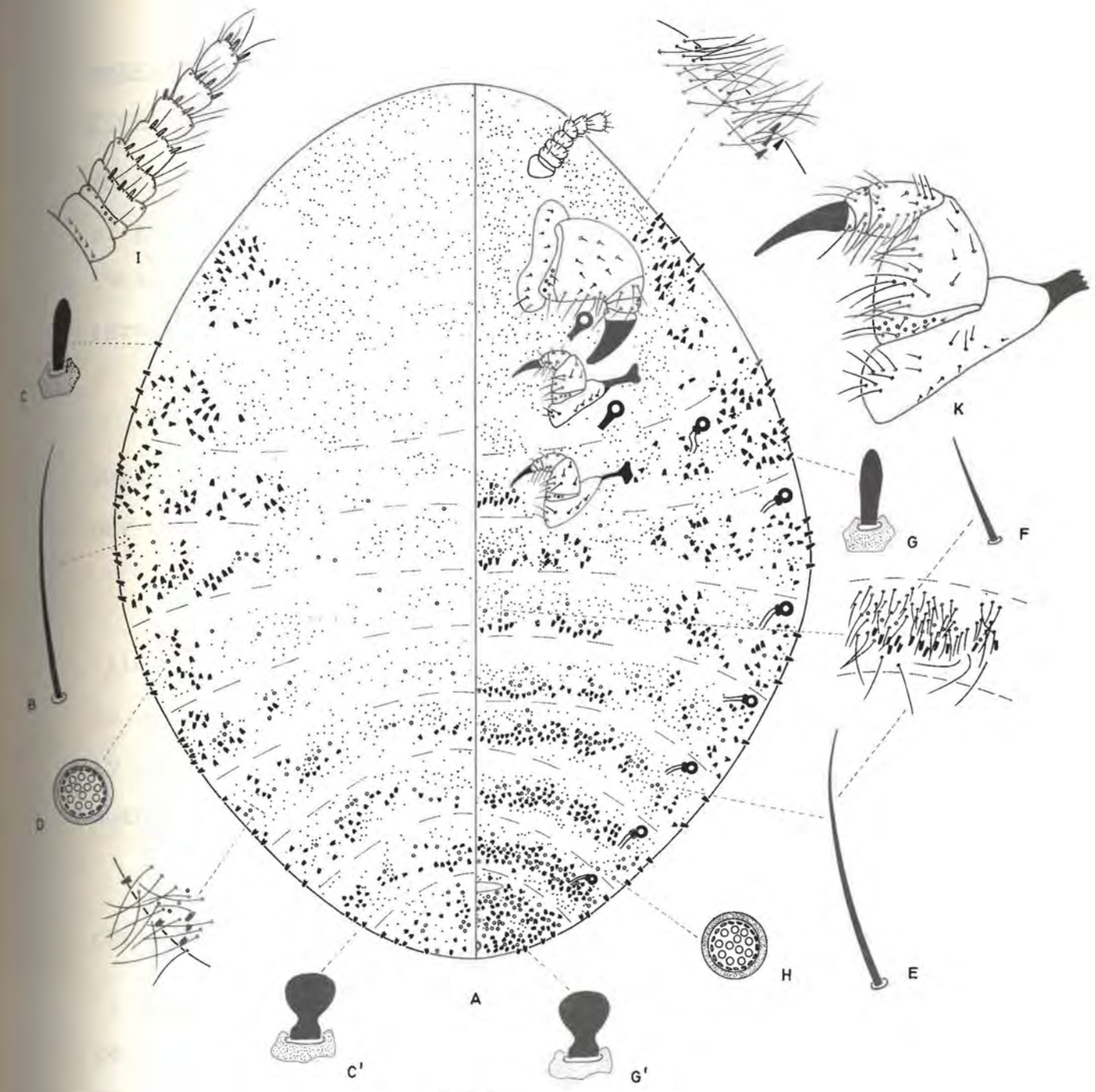

PLATE 11

MARGARODES RUBER BRAIN, 1915

Margarodes ruber Brain, 1915 : 189

Promargarodes ruber (Brain); Jakubski, 1965 : 136

This species was first described from material found on roots of grass in Pretoria, collected by C.K. Brain during October, 1914. A number of cysts and 7 adult females were studied (Brain, 1915).

EGG, FIRST INSTAR LARVA AND MALE

These stages have not been described in previous publications nor have they been observed by the author.

NYMPH OF THE CYST STAGE

"Almost spherical, about 2 mm in diameter, white, translucent to semi-transparent, the red colour of the female being plainly visible before emergence" (Brain, 1915). Not seen by the author.

ADULT FEMALE (Plate 12)

GENERAL APPEARANCE

"2 mm to 2,5 mm long when extended, elongated with a distinct constriction at the junction of the cephalothorax with the abdomen. Colour deep reddish-yellow to carrot colour. Two small scarlet eye-spots between the antennae. Antennae and legs pale, except the stout front claws, which are brownish-black" (Brain, 1915). Live specimens not seen by the author.

DESCRIPTION

Body (Fig. A) oval; 2,51 (2,16 - 2,88) mm long; 1,86 (1,52 - 2,00) mm wide; with definite constriction opposite posterior

pair of thoracic spiracles; distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 78,7 (70,00 - 95,2) long; distributed over whole dorsum in marginal and median areas; distributed over whole surface of each abdominal segment.

Short setae: Absent on whole dorsal surface.

Spines (Fig. C and C^1): Sharply pointed; 34,5 (29,0 - 41,9) long on anterior part of body; occurring densely in marginal areas of thorax, becoming less numerous, more bluntly pointed and also shorter (15,8 ; 11,0 - 19,5) towards posterior end of abdomen; absent in median areas of whole body.

Pores (Fig. D): Multilocular derm pores circular, 10,6 (9,8 - 11,4) in diameter; with variation in diameter similar over entire body; with 15 to 18 microloculi in an outer circle and 7 to 9 macroloculi in inner circle with a central loculus; dispersed irregularly on head, thorax and abdomen; very rare and sometimes absent in marginal areas; in median areas their numbers decrease from thorax to posterior part of abdomen.

VENTRAL SURFACE

Long setae (Fig. E): 81,9 (72,4 - 97,6) long; all areas of body as densely covered as dorsum except for narrow area between median and marginal areas of abdomen where they are less numerous or absent; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. F): 37,2 (26,2 - 44,3) long; situated

amongst the long setae but, occurring only in median areas of thorax and abdomen.

Spines (Fig. G and G^1): Sharply pointed; 36,7 (34,5 - 41,4) long on anterior part of body; occurring densely in marginal area of thorax, becoming less numerous, more bluntly pointed and also shorter (14,3 ; 12,4 - 15,2) towards posterior end of abdomen; in median area occurring from metathorax, becoming more numerous and also more bluntly pointed and shorter towards posterior end of abdomen; absent or in low numbers in narrow area between median and marginal areas of abdomen.

Pores (Fig. D): Multilocular derm pores circular, 10,6 (9,8 - 11,4) in diameter; with variation in diameter similar over entire body; with 15 to 18 microloculi in an outer circle and 7 to 9 macroloculi in inner circle with a central loculus; occurring on head but absent on thorax and abdomen.

Antennae (Fig. H): Ten segmented; 406,5 (322,2 - 491,7) long. Segment I twice as wide as long, with 3 to 6 minute setae placed in a row at the base. Segment II half as long as segment III, with 2 to 5 long setae, 3 to 7 minute setae placed in a row and with 1 to 3 large sensory pores at distal end. Segments III to IX all of about the same length but diminishing gradually in width; each with variable numbers of long, hairlike setae (52,9 ; 38,1 - 62,4) and short (23,2 ; 19,5 - 25,5), bluntly pointed, fleshy setae distributed around distal end of each segment. Segment X longer and narrower than segment IX, rounded at apex with 4 to 6 long hairlike setae (68,9 ; 64,3 - 74,3) and 7 to 11 short, fleshy setae (28,8 ; 23,8 - 31,2) placed apically.

Antennal segment	Length	Width
I	83,6 (60,0 - 95,2)	159,2 (134,8 - 186,9)
II	24,0 (20,0 - 27,6)	142,8 (115,5 - 163,6)
III	40,8 (32,1 - 45,9)	146,3 (125,7 - 166,7)
IV	33,3 (30,2 - 37,6)	138,4 (119,0 - 151,6)
V	32,9 (28,8 - 36,7)	135,1 (121,0 - 150,0)
VI	37,4 (30,2 - 44,5)	126,9 (105,1 - 142,9)
VII	31,7 (25,5 - 52,4)	118,0 (100,2 - 135,7)
VIII	35,4 (22,6 - 47,6)	109,7 (95,2 - 121,9)
IX	40,9 (27,6 - 53,8)	97,3 (92,4 - 102,9)
X	77,5 (69,8 - 95,2)	76,7 (71,0 - 86,0)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 313,5 (252,8 - 376,9) long; 327,0 (266,7 - 363,0) wide with long setae (126,9 ; 99,5 - 161,0) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 4 to 6 long setae and 2 minute setae on each of posterior and anterior sides. Tarsus with 4 to 5 long setae on posterior side and 3 on anterior side as well as 4 dorsal pores grouped together proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with 2 long seta-like digitules on each of posterior and anterior sides.

Middle and hind legs (Fig. I): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 3 long setae on ventral side; 5 to 7 short setae on posterior side and 6 to 8 on anterior side. Trochanter with 2 to 3 long setae on ventral side; 1 to 2 minute setae, 0 to 1 long seta and 3 sensory pores on posterior side; 1 to 4 minute setae, 0 to 2 long setae and 3 to 5 sensory pores

on anterior side. Femur 175,6 (166,2 - 183,6) long; 155,8 (114,5 - 185,7) wide with long ventral setae (95,6 ; 65,5 - 111,4) and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 143,8 (124,8 - 171,0) long; 92,3 (77,4 - 103,3) wide with 2 long ventral setae (43,8 ; 41,0 - 50,0) at distal end; 3 to 6 long setae and 1 to 3 minute setae on each of posterior and anterior sides. Tarsus with 2 long ventral setae at distal end; 2 to 3 long setae on each of posterior and anterior sides; 4 dorsal pores grouped together proximally. Claw 74,2 (67,6 - 83,8) long; 8,8 (6,7 - 10,2) wide; curved; smooth on inner surface; heavily sclerotized except basally; with 1 long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 2 to 4 small pores next to opening on posterior side. Atrium 58,8 (53,1 - 63,8) in diameter; with 6 to 10 large multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; simple pores absent.

Abdominal spiracles: Six pairs; twice as small as thoracic spiracles; all about of the same size; first pair situated more marginally. Atrium 27,5 (23,8 - 31,7) in diameter; with 3 to 6 multilocular pores arranged in a circle on the peritreme wall just inwards to the atrium; simple pores absent.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips, with or without setae.

Anal opening: Circular or oval; sclerotized; situated

apically or sub-apically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Pretoria, October 1914, on roots of grass, C.K. Brain, collection no. 11, type 1 female, paratype 2 females (USNM) and paratype 2 females (PPRI).

PLATE AND LETTERING

Plate 12: *Margarodes ruber* Brain, adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal long spine

C^1 = dorsal short spine

D = dorsal and ventral multilocular derm pore

E = ventral long seta

F = ventral short seta

G = ventral long spine

G^1 = ventral short spine

H = antenna

I = hind leg

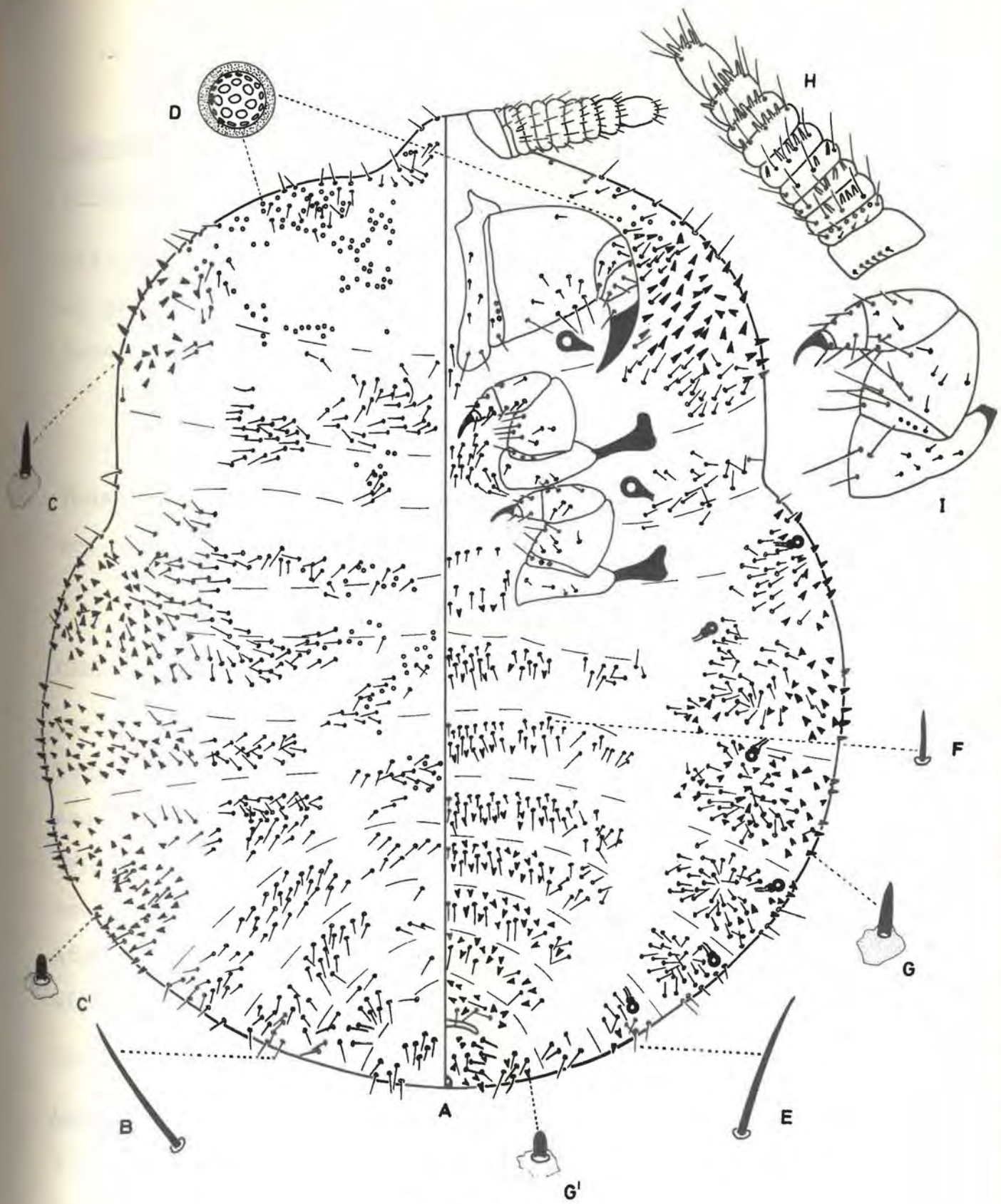

PLATE 12

MARGARODES TRIMENI GIARD, 1897

Margarodes trimeni Giard, 1897 : 684

Coccionella trimeni (Giard) Lindinger, 1954 : 615

This species was first described from material found at roots of grass in Ceres, collected by C.P. Lounsbury. Two adult females and some cysts were studied (Giard, 1897).

EGG, FIRST INSTAR LARVA AND MALE

These stages have not been described in previous publications nor have they been observed by the author.

NYMPH OF THE CYST STAGE (Plate 13)

GENERAL APPEARANCE

Irregular in shape, oval, narrower at one end, varying in length to a maximum of 6,3 mm in length. Cyst wall thick and very hard, constructed of distinct overlapping scales (Fig. 28). Outer surface smooth; yellow or bronze to light brown with a metallic lustre. Of the species found in South Africa, this is the only one with an iridescent lustre and without a spherical form.

DESCRIPTION

Antennae: Small rounded protrusion in shallow pit with 3 to 4 minute bluntly pointed, fleshy setae at distal end.

Mouthparts: Sclerotized clypeo-labral complex situated opposite thoracic spiracles. Stylets forming an oblong loop; approximately twice as long as body when extended. Labium sclerotized; with short setae.

Pores absent.

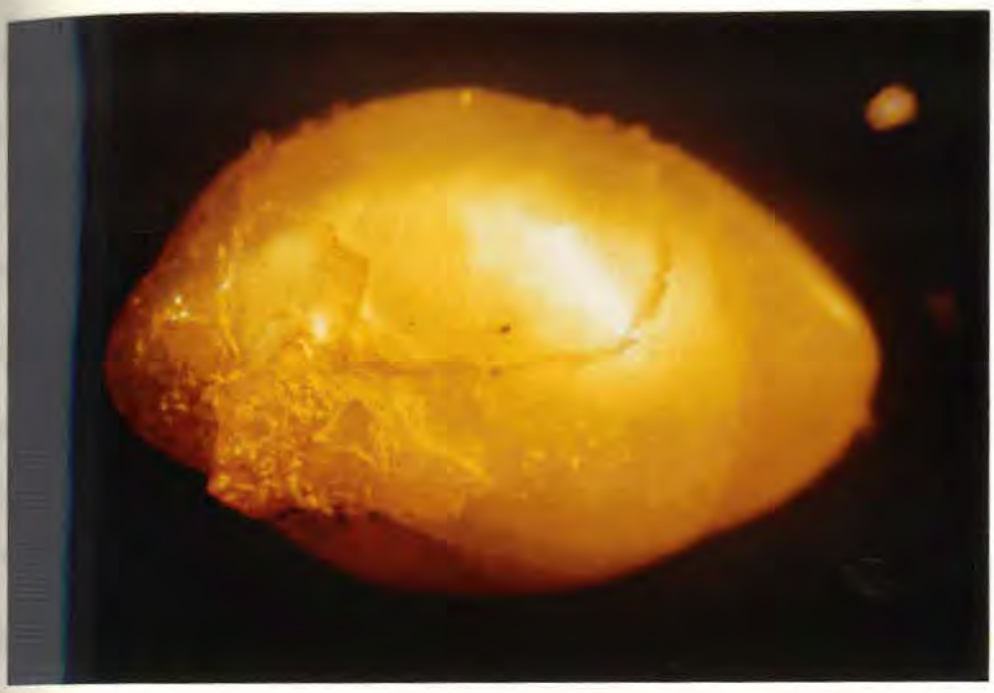

Fig. 28 : Cyst of Margarodes trimeni Giard

Thoracic spiracles: Two pairs with circular openings; 2 to 3 small pores grouped together next to opening on posterior side. Atrium 38,91 (23,81 - 47,62) in diameter with 10 to 12 multilocular pores.

Abdominal spiracles: Six pairs; first pair 2 to 3 times smaller than thoracic spiracles and situated more marginally; size decreases towards posterior end of abdomen; last pair usually inconspicuous. Atrium of first pair 16,81 (10,71 - 23,81) in diameter with 3 to 6 multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 2 cicatrices arranged in a line at each side of anus. Cicatrices occur between anus and last pair of abdominal spiracles.

Genital scar a transverse line situated near anal opening.

ADULT FEMALE (Plate 14)

GENERAL APPEARANCE

"In appearance this insect greatly resembles M. capensis, but is of a slightly smaller size" (Brain, 1915). Live specimens not seen by the author.

DESCRIPTION

Body (Fig. A): Elongated 4,62 (3,92 - 5,04) mm long; 3,38 (2,48 - 4,00) mm wide with distinct segmentation on both ventral and dorsal surfaces.

DORSAL SURFACE

Long setae (Fig. B): 93,1 (91,0 - 95,2) long; distributed evenly on whole dorsum in marginal and median areas; distributed over whole surface of each abdominal segment.

Short setae: Absent on dorsal surface.

Spines (Fig. C): Bluntly pointed; occurring densely in marginal area of thorax, becoming less numerous to posterior end of abdomen; in median area dispersed irregularly only at posterior part of abdomen; length in all areas approximately the same (25,0 ; 23,8 - 26,2).

Pores (Fig. D): Multilocular derm pores circular, 11,5 (9,8 - 12,6) in diameter; variation in diameter similar over whole area of occurrence; with 12 to 13 microloculi in an outer circle, 5 to 6 macroloculi in inner circle and without a central loculus; absent on head and thorax; occurring only from third or fourth segment of abdomen in marginal and median areas, becoming more numerous towards posterior end of abdomen; density the same in marginal as in median area.

VENTRAL SURFACE

Long setae (Fig. E): 93,1 (91,0 - 95,2) long; more numerous than on dorsum; occurring on whole body but less numerous or absent in narrow area between median and marginal areas of abdomen; more dense in median areas than in marginal areas of whole body; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. F): 39,5 long; situated amongst the long setae and distributed in same pattern as the latter.

Spines (Fig. G and G^1): Bluntly pointed; 29,0 (23,8 - 34,1) long on anterior part of body; occurring densely in marginal area of thorax, becoming less numerous towards posterior end of abdomen; occurring in median area from metathorax becoming more numerous, more bluntly pointed, thicker and also shorter (16,6 ; 15,7 - 17,4) towards posterior end of abdomen; occurring on whole ventral surface except for narrow area between median and marginal areas of abdomen.

Pores (Fig. H): Multilocular derm pores circular, 11,5 (9,8 - 12,6) in diameter; variation in diameter similar over whole area of occurrence; with 12 to 13 microloculi in an outer circle, 5 to 6 macroloculi in inner circle and without a central loculus; absent on head and thorax; occurring only from third or fourth segment of abdomen in marginal and median areas, becoming more numerous towards posterior end of abdomen; density the same in marginal as in median area.

Antennae (Fig. I): Eight segmented; 620,5 (519,4 - 680,6) long. Segment I one and a half times as wide as long, with one short rigid seta as well as 4 minute setae placed in a

row at the base. Segment II almost three times shorter than segment III, with 5 long setae; the presence of sensory pores could not be determined. Segments III to VII all of about the same length but diminishing gradually in width; each with variable numbers of long hairlike setae (44,3) and short (25,6 ; 23,8 - 29,5), bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 5 to 6 long hairlike setae (79,7 ; 71,4 - 85,7) and 4 to 7 short fleshy setae (35,3 ; 27,4 - 44,0) placed apically.

Antennal segment	Length	Width
I	114,4 (100,7 - 126,0)	171,1 (150,2 - 206,7)
II	32,0 (21,4 - 38,8)	138,7 (123,1 - 158,8)
III	79,4 (70,7 - 87,4)	145,7 (134,0 - 166,7)
IV	92,1 (72,6 - 105,5)	129,6 (113,8 - 147,9)
V	81,7 (58,6 - 98,1)	107,2 (95,5 - 119,0)
VI	83,7 (60,0 - 95,2)	98,6 (87,9 - 111,7)
VII	77,4 (58,3 - 87,4)	85,4 (69,8 - 102,9)
VIII	101,7 (90,2 - 113,1)	72,3 (60,5 - 86,2)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 471,5 (388,9 - 559,3) long; 464,4 (370,4 - 543,5) wide with long setae (159,0) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 4 long setae and one minute seta on each of posterior and anterior sides. Tarsus with 3 long setae each on posterior and anterior sides as well as 3 dorsal pores grouped together proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with

one long seta-like digitule on each of posterior and anterior sides.

Middle and hind legs (Fig. J): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 4 long setae on ventral side and numerous short setae on posterior and anterior sides. Trochanter with 3 to 4 long setae on ventral side and 5 sensory pores on each of posterior and anterior sides. Femur 268,1 (221,3 - 305,6) long; 225,2 (185,2 - 255,6) wide with long ventral setae (139,0) and short rigid setae on posterior and anterior sides; dorsal side almost completely bare. Tibia 154,5 (117,9 - 178,6) long; 88,9 (86,2 - 92,4) wide with 2 long ventral setae (57,8 ; 54,3 - 62,4) at distal end; 1 to 5 long setae and one minute seta on each of posterior and anterior sides. Tarsus with 2 long setae at distal end; 3 long setae on posterior as well as on anterior side; 3 dorsal pores grouped together proximally. Claw 193,1 (182,4 - 200,9) long; 17,5 (15,2 - 21,0) wide; slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 2 small pores grouped together next to opening on posterior side. Atrium 101,4 (87,6 - 119,0) in diameter; with 4 large multilocular pores arranged in a circle on the peritreme wall, just inwards to the atrium; 10 simple pores in an inner circle.

Abdominal spiracles: Six pairs; three times smaller than thoracic spiracles; all of about the same size; first pair situated more marginally. Atrium 27,3 (22,1 - 32,1) in diameter; with unknown number of pores.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips covered with short, rigid setae or without such setae.

Anal opening: Circular or oval; sclerotized; situated subapically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Ceres, 1898, C.P. Lounsbury, collection no. 8 of C.K. Brain, part of type material 2 females (USNM) and part of type material 2 females (PPRI). In addition, the following material was studied: Breë River, November 1976, C.A. de Klerk, collection no. MD 17, 5 cysts (ØVRI).

PLATES AND LETTERING

Plate 13: Margarodes trimeni Giard, nymph of the cyst stage (with labium shown to one side)

Plate 14: Margarodes trimeni Giard, adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal spine

D = dorsal multilocular derm pore

E = ventral long seta

F = ventral short seta

G = ventral long spine

G^1 = ventral short spine

H = ventral multilocular derm pore

I = antenna

J = hind leg

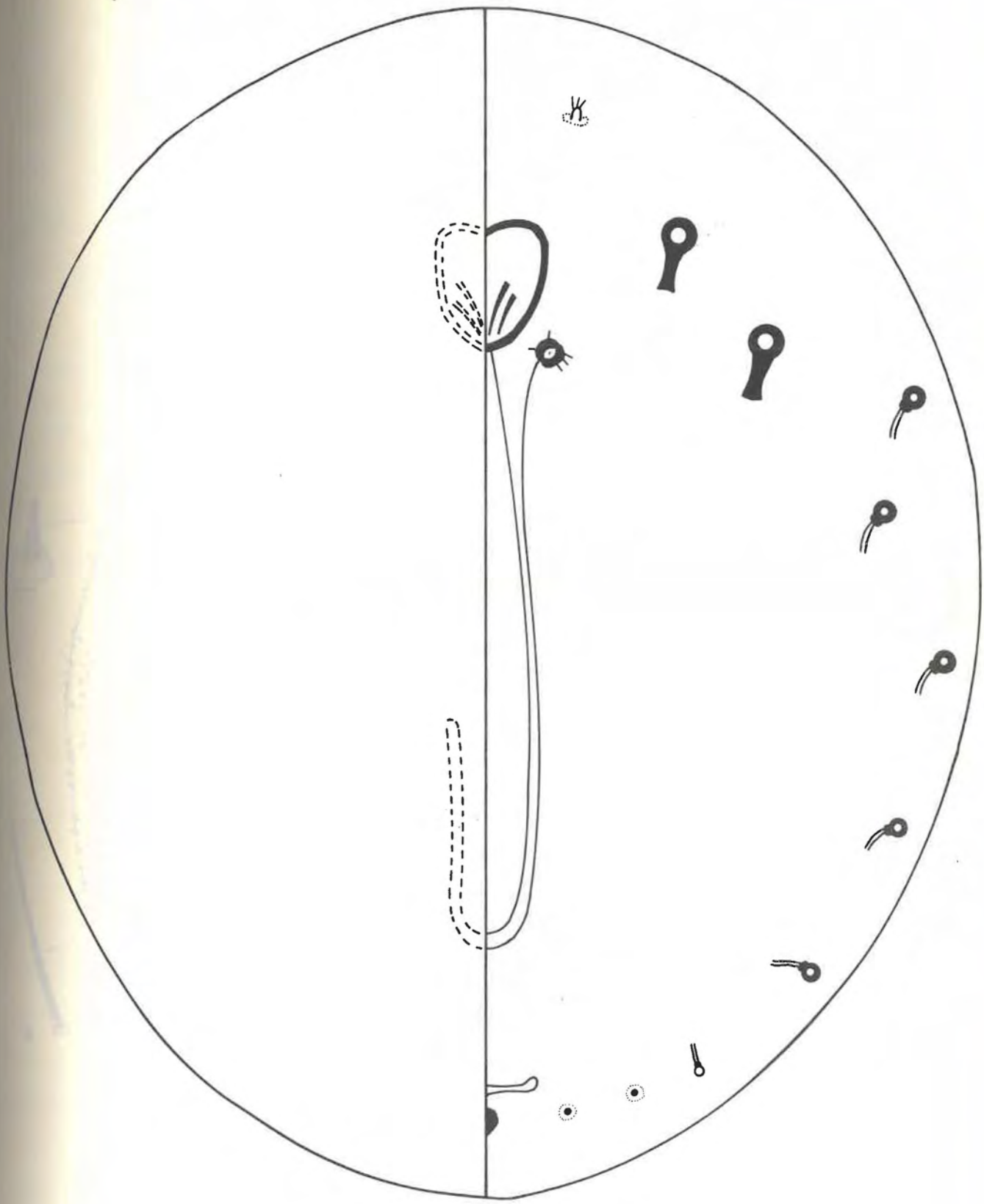

PLATE 13

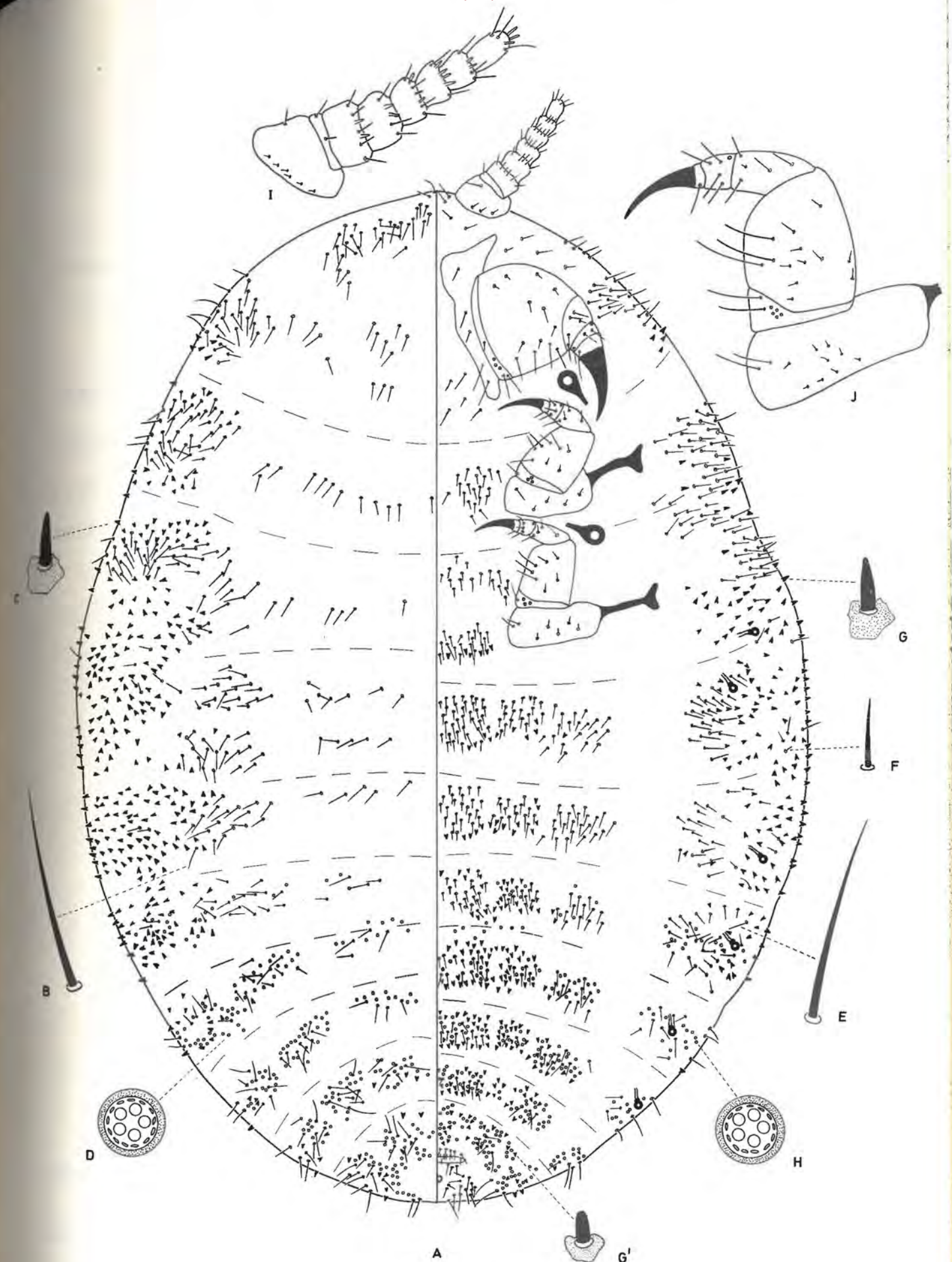

PLATE 14

MARGARODES UPINGTONENSIS DE KLERK sp. n.

EGG, FIRST INSTAR LARVA AND MALE

These stages have not been observed by the author.

NYMPH OF THE CYST STAGE (Plate 15)

GENERAL APPEARANCE

Spherical, varying in size to a maximum of 3 mm in diameter. Cyst wall thin and very soft. Outer surface smooth (Fig. 29); white to pale yellow in colour.

Fig. 29 : Cyst of Margarodes upingtonensis sp.n.

DESCRIPTION

Antennae: Small rounded protrusion with one minute, bluntly pointed, fleshy seta.

Mouthparts: Sclerotized clypeo-labral complex situated oppo-

site thoracic spiracles. Stylets forming an oblong loop; approximately twice as long as body when extended. Labium sclerotized; with 4 to 8 short setae.

Pores: 4 to 7 multilocular derm pores situated around labium, each with numerous microloculi in an outer circle and 3 to 4 macroloculi in the centre; 2 to 7 multilocular derm pores grouped together near opening of thoracic spiracles on anterior side, each with 6 to 12 microloculi in an outer circle and 2 to 3 macroloculi in the centre.

Thoracic spiracles: Two pairs with circular openings; 2 to 4 small pores grouped together next to opening on posterior side. Atrium 28,3 (17,6 - 34,1) in diameter with 10 to 16 multilocular pores.

Abdominal spiracles: Seven pairs; first pair slightly smaller than thoracic spiracles and situated more marginally; size decreases slightly towards posterior end of abdomen. Atrium of first pair 24,0 (17,6 - 28,6) in diameter with 6 to 10 multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 6 to 15 cicatrices, usually arranged in a line of vertical pairs on both sides of anus. Cicatrices occur between anus and fifth pair of abdominal spiracles.

Genital scar a transverse line situated anteriorly near anal opening.

ADULT FEMALE (Plate 16)

GENERAL APPEARANCE

Adult female small and white to pale yellow in colour. Seg-

mentation clearly visible on both ventral and dorsal sides.

DESCRIPTION

Body (Fig. A) oval, 3,58 (2,88 - 4,16) mm long and 2,95 (2,16 - 3,68) mm wide.

DORSAL SURFACE

Long setae (Fig. B): 98,0 (86,2 -109,0) long; occurring in low numbers on whole dorsum in marginal and median areas; grouped together on centre line of each abdominal segment.

Short setae: Absent on whole dorsal surface.

Spines (Fig. C and C^1): Bluntly pointed; 26,7 (23,3 - 34,5) long on anterior part of body; occurring densely in marginal area of thorax, becoming less numerous, more bluntly pointed, much thicker and also shorter from mesothorax (25,3 ; 23,8 - 28,3) towards posterior end of abdomen; absent on prothorax; in median area only the shorter and thicker spines occur and only on the last 4 abdominal segments.

Pores (Fig. D): Multilocular derm pores circular, 11,3 (9,5 - 12,9) in diameter; variation in diameter similar over entire body; with 12 to 16 microloculi in an outer circle, 4 to 6 macroloculi in inner circle and with or without a central loculus; dispersed irregularly on head, thorax and abdomen; very rare and sometimes absent on head and prothorax; in median and marginal areas their numbers increase from mesothorax towards posterior end of abdomen.

VENTRAL SURFACE

Long setae (Fig. E): 99,5 (80,0 - 124,5) long; all areas of body more densely covered than dorsum except on narrow area

between median and marginal areas of abdomen where they are less numerous or absent; grouped together on centre line of each abdominal segment.

Short setae (Fig. F): 43,0 (37,1 - 49,5) long; occurring only in median areas of thorax and abdomen.

Spines (Fig. G and G^1): Bluntly pointed; 29,9 (27,1 - 34,5) long on anterior part of body; occurring densely in marginal areas of thorax becoming less numerous, more bluntly pointed, much thicker and also shorter from mesothorax 25,3 (23,8 - 28,3) towards posterior end of abdomen; absent on prothorax; in median areas occurring from metathorax, becoming more numerous and also shorter and thicker towards posterior part of abdomen; absent or in low numbers in narrow area between median and marginal areas of abdomen.

Pores (Fig. H): Multilocular derm pores circular, 11,3 (9,5 - 12,9) in diameter; variation in diameter similar over entire body; with 12 to 16 microloculi in an outer circle, 4 to 6 macroloculi in inner circle and with or without a central loculus; dispersed irregularly on head, thorax and abdomen; very rare and sometimes absent on head and prothorax; in median and marginal areas their numbers increase from mesothorax towards posterior end of abdomen.

Antennae (Fig. I): Eight-segmented; 484,5 (419,4 - 572,2) long. Segment I twice as wide as long, dorsally with 3 to 7 minute setae. Segment II ½ as long as segment III, with 3 to 7 long setae, 2 to 7 minute setae placed in a ventral row and with 1 to 4 large sensory pores dorsally at distal end. Segments III to VII all of about the same length but diminishing gradually in width; each with variable numbers

of long hairlike setae (55,0 ; 47,6 - 63,3) and short (31,4 ; 25,7 - 36,2) bluntly pointed, fleshy setae distributed around distal end of each segment. Segment VIII longer and slightly narrower than segment VII, rounded at apex with 4 to 8 long hairlike setae (53,1 ; 45,2 - 64,3) and 6 to 15 short fleshy setae (35,6 ; 30,5 - 42,6) placed apically.

Antennal segment	Length	Width
I	98,2 (88,1 - 113,3)	175,5 (147,1 - 200,0)
II	38,5 (32,4 - 47,9)	129,3 (112,6 - 147,1)
III	51,0 (42,1 - 60,7)	136,4 (122,1 - 153,6)
IV	60,3 (47,9 - 78,1)	120,6 (104,3 - 144,8)
V	59,6 (49,8 - 71,7)	108,6 (95,5 - 129,0)
VI	53,6 (39,8 - 65,7)	98,4 (88,3 - 114,8)
VII	56,3 (44,5 - 69,3)	89,5 (77,9 - 106,2)
VIII	80,3 (71,4 - 95,2)	81,3 (68,8 - 93,8)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 360,3 (282,4 - 444,4) long; 402,3 (292,6 - 477,8) wide with long setae (92,6 ; 72,9 - 119,0) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 6 to 12 long setae and 1 to 2 minute setae on posterior side; 6 to 13 long setae and 1 to 3 minute setae on anterior side. Tarsus with 4 to 7 setae on posterior side and 3 to 8 on anterior side as well as 3 to 7 dorsal pores grouped together proximally; 5 to 6 small pores placed near each other in a ventral row on anterior side. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with 2 long seta-like digitules on each of posterior and anterior sides.

Middle and hind legs (Fig. J): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 2 to 5 long setae on ventral side; posterior side with 6 to 8 long and short setae; anterior side with 6 to 13 long and short setae. Trochanter with 2 to 6 long setae on ventral side; 2 to 3 minute setae, 0 to 2 long setae and 5 to 9 sensory pores on each of posterior and anterior sides. Femur 192,8 (159,5 - 236,1) long; 204,7 (166,7 - 250,0) wide, with long ventral setae (72,0 ; 60,0 - 85,7); short rigid setae on posterior and anterior sides as well as on dorsal side. Tibia 109,0 (95,2 -125,7) long; 95,3 (77,6 - 119,0) wide, with 3 to 6 long ventral setae (62,2 ; 48,8 - 75,2); 3 to 6 long setae and one minute seta on posterior side; 2 to 5 long setae and 1 to 2 minute setae on anterior side. Tarsus with 2 long ventral setae; 3 to 4 long setae on posterior side; 2 long setae on anterior side; 3 to 4 dorsal pores grouped together proximally; 3 to 6 minute pores placed in a ventral row on anterior side. Claw 149,9 (128,6 - 175,5) long; 21,0 (16,2 - 24,0) wide; curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs with circular openings; 3 to 5 small pores next to opening on posterior side. Atrium 80,0 (71,4 - 87,6) in diameter; with 4 to 11 large multilocular pores arranged in an outer circle on the peritreme wall just inwards to the atrium; 5 to 12 simple pores in inner circle.

Abdominal spiracles: Seven pairs; half as small as thoracic spiracles; all of about the same size; first pair situated more marginally. Atrium 51,8 (47,6 - 57,9) in diameter; with

3 to 8 multilocular pores arranged in an outer circle on the peritreme wall, just inwards to the atrium; 3 to 8 simple pores in inner circle.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly near anus with distinct lips covered with short, rigid setae.

Anal opening: Circular; sclerotized; situated apically or sub-apically on ventral surface in middle of small naked area.

MATERIAL EXAMINED

South Africa, Upington, January 1974, on roots of Kikuju grass, A. Calitz, collection no. MD 10 of C.A. de Klerk. Described from a female holotype (MD 10/19) and 9 female paratypes, (OVRI). In addition to the type-series the following material was studied: Upington, August 1977, on roots of Kikuju grass, A. Calitz, collection no. MD 21 of C.A. de Klerk, 6 cysts (OVRI).

NOTES

This species closely resembles M. salisburiensis Hall, 1940 from which it differs mainly by the following characters:

1. Multilocular derm pores in M. salisburiensis are absent on the head, thorax and first three abdominal segments, in M. upingtonensis they occur on head; thorax and abdomen.
2. The number of macroloculi in the multilocular derm

pores of M. salisburiensis is more than 25, while that of M. upingtonensis is between 4 and 6.

3. M. salisburiensis is more densely covered with longer setae than M. upingtonensis.

4. Spines occur in marginal area from mesothorax to posterior end of abdomen in M. upingtonensis; in M. salisburiensis they are found from the metathorax to posterior end of abdomen.

PLATES AND LETTERING

Plate 15: Margarodes upingtonensis sp. n., nymph of the cyst stage (with labium shown to one side)

Plate 16: Margarodes upingtonensis sp. n., adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal long spine

C^1 = dorsal short spine

D = dorsal multilocular derm pore

E = ventral long seta

F = ventral short seta

G = ventral long spine

G^1 = ventral short spine

H = ventral multilocular derm pore

I = antenna

J = hind leg

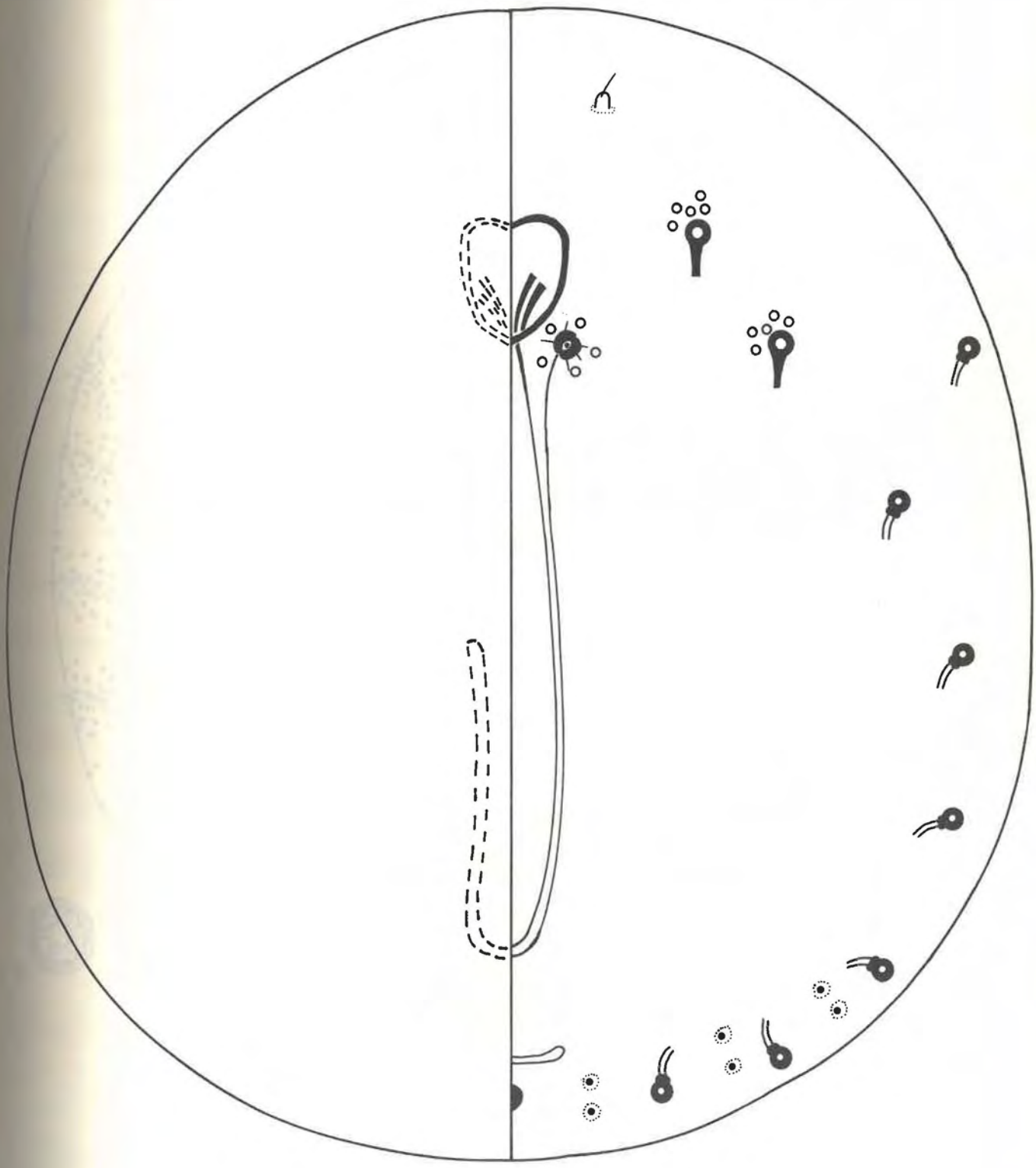

PLATE 15

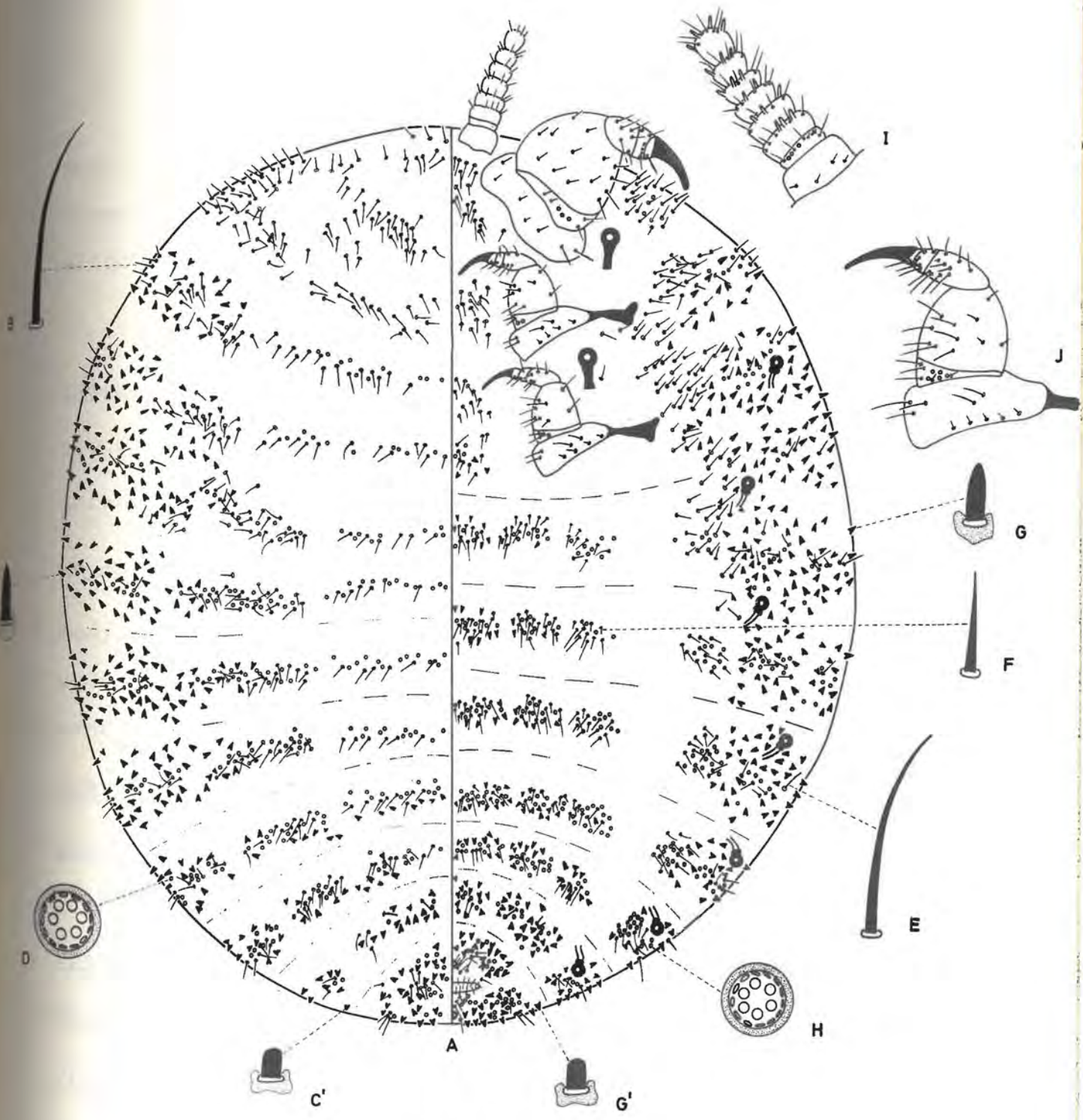

PLATE 16

MARGARODES VREDENDALENSIS DE KLERK sp. n.

EGG

Newly laid eggs are with a smooth glossy-white surface; elongated; 630 (550 - 675) long, 263 (225 - 300) wide; slightly curved with one end more bluntly pointed.

FIRST INSTAR LARVA

GENERAL APPEARANCE

First instar larva creamy-white in colour, elongated with antennae and legs clearly visible.

DESCRIPTION

Body elongated, 0,95 (0,89 - 1,00) mm long and 0,31 (0,29 - 0,34) mm wide. Abdomen with 8 distinct segments; last segment invaginated apically.

DORSAL SURFACE

Setae: Minute, rigid and inconspicuous setae distributed sparsely and irregularly on head, thorax and abdomen.

Spines absent.

Pores absent.

VENTRAL SURFACE

Setae: Minute, rigid and inconspicuous setae occur sparsely and irregularly on head, thorax and abdomen. Two short, rigid setae are found, one on each side of anus on last abdominal segment. Two very long (179,4 ; 100,0 - 250,0) apical setae occur on last abdominal segment.

Spines absent.

Pores: Two multilocular derm pores situated near labium, with numerous microloculi in an outer circle and 3 macroloculi in the centre.

Antennae 4 segmented; geniculated, with club-shaped flagellum; distance between antennae approximately the same as the width of basal segment. Segment I 1½ times as long as wide, with 3 to 4 short setae. Segment II half as long as segment I and slightly narrower, with 3 to 4 short setae. Antenna bending outwards almost rectangularly at this segment. Segment III 1½ times as wide as long, with 4 to 5 short setae. Segment IV 2½ times as long as segment III; rounded at apex; with 5 long setae distributed around the middle as well as 5 to 6 long setae, 2 cylindrical, fleshy setae and 2 club-shaped, fleshy setae placed apically.

Antennal segment	Length	Width
I	39,5 (32,1 - 42,9)	27,7 (23,8 - 32,9)
II	23,4 (19,5 - 27,6)	18,9 (15,5 - 20,7)
III	16,2 (14,1 - 23,8)	28,2 (26,2 - 29,8)
IV	53,5 (47,6 - 58,6)	37,7 (36,9 - 39,1)

Front legs placed 129,1 (85,0 - 166,7) apart from middle legs. Coxa with 3 to 4 minute setae. Trochanter small with 2 to 3 minute setae; 2 large sensory pores on each of posterior and anterior sides. Femur large, with 2 to 3 minute setae on each of posterior and anterior sides. Tibia with 3 to 4 setae. Tarsus with 4 setae and with a small rounded protrusion proximally. Claw short, curved, smooth on inner surface, heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Segment	Length	Width
Coxa	33,8 (25,0 - 39,5)	34,6 (30,2 - 40,5)
Trochanter	27,3 (23,8 - 31,4)	20,4 (18,6 - 21,7)
Femur	59,2 (47,6 - 67,9)	30,6 (26,2 - 37,1)
Tibia	31,8 (25,0 - 36,7)	17,8 (15,7 - 20,0)
Tarsus	17,5 (13,8 - 20,7)	13,2 (9,5 - 16,4)
Claw	19,7 (15,5 - 23,8)	

Middle and hind legs: Middle legs placed 105,5 (81,9 - 131,4) apart from hind legs. Both pairs similar in size and shape. Coxa with 3 to 4 minute setae. Trochanter small, with 1 minute seta; 2 large sensory pores on each of posterior and anterior sides. Femur large, with 1 to 2 minute setae on each of posterior and anterior sides. Tibia with 2 to 3 setae. Tarsus with 2 setae and with a small rounded protrusion proximally. Claw long, almost straight, smooth on inner surface, heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Segment	Length	Width
Coxa	27,7 (23,8 - 32,1)	29,3 (27,4 - 31,2)
Trochanter	17,0 (11,2 - 20,0)	17,1 (17,1 - 18,3)
Femur	52,5 (50,0 - 55,4)	23,2 (21,4 - 24,5)
Tibia	33,6 (31,0 - 37,6)	14,5 (11,9 - 16,2)
Tarsus	24,4 (22,9 - 26,9)	11,8 (7,1 - 13,3)
Claw	34,4 (31,9 - 36,9)	

Thoracic spiracles: Two pairs with circular openings; one small pore near opening on posterior side. Atrium cylindrical.

Abdominal spiracles: Seven pairs; second and third pair slightly smaller than thoracic spiracles; first pair and

last 4 pairs inconspicuous and much smaller than second and third pairs.

Mouthparts: Sclerotized clypeo-labral complex situated between front and middle legs. Stylets forming an oblong loop; approximately 1½ times as long as body when extended. Labium situated posterior to clypeo-labral complex and opposite first thoracic spiracles; sclerotized with 4 to 6 short setae.

Anal opening circular; sclerotized; situated sub-apically on last abdominal segment of the ventral surface.

NYMPH OF THE CYST STAGE (Plate 17)

GENERAL APPEARANCE

Spherical, varying in size to a maximum of 8,6 mm in diameter. Cyst wall thick and very hard. Outer surface rough, like the surface of a wart (Fig. 30); light to dark brown but a bright yellow when the outer layers are removed.

DESCRIPTION

Antennae: Small rounded protrusion in deep pit with minute, bluntly pointed, fleshy setae at distal end.

Mouthparts: Sclerotized clypeo-labral complex situated opposite thoracic spiracles. Stylets forming an oblong loop; approximately as long as body when extended. Labium sclerotized; with about 12 short setae.

Pores: 5 to 8 multilocular derm pores situated around labium. Micro- and macroloculi could not be observed.

Thoracic spiracles: Two pairs with circular openings; 3 to 4 small pores grouped together next to opening on posterior

Fig. 30 : Cyst of Margarodes vredendalensis sp.n.

side. Atrium 100,9 (92,6 - 107,4) in diameter with about 30 multilocular pores.

Abdominal spiracles: Seven pairs; first pair about the same size as thoracic spiracles and situated more marginally; becoming smaller towards posterior end of abdomen. Atrium of first pair 95,0 (92,6 - 101,9) in diameter with about 30 multilocular pores.

Anal opening circular, situated sub-apically on ventral surface with 13 to 16 cicatrices, arranged in a line of 2 vertical pairs at each side of anus as well as 5 to 8 scattered around anal opening. Cicatrices occur only between anus and last pair of abdominal spiracles.

Genital scar a transverse line situated anteriorly near anal

opening.

ADULT FEMALE (Plate 18)

GENERAL APPEARANCE

The adult female varies greatly in size, yellow in colour with claws dark brown and the body is densely covered with long hairlike setae. Segmentation is plainly visible on both ventral and dorsal sides.

DESCRIPTION

Body (Fig. A) oval; 6,72 (5,20 - 8,75) mm long; 5,35 (4,48 - 6,72) mm wide; with distinct segmentation on dorsal and ventral surfaces of abdomen; segmentation not distinct anterior to metathorax.

DORSAL SURFACE

Long setae (Fig. B): 445,7 (370,4 - 509,3) long; thin and hairlike; numerous; distributed on whole dorsum in marginal and median areas; distributed over whole surface of each abdominal segment.

Short setae (Fig. C): 82,6 (55,5 - 97,2) long; rigid; occurring in low numbers amongst the long setae and distributed as the latter.

Medium setae: Vary in length between short and long setae; hairlike; distributed densely amongst the long setae on whole dorsum in marginal and median areas.

Spines (Fig. D): Bluntly pointed; 33,2 (29,0 - 38,6) long on anterior part of body; occurring in low numbers in marginal area of thorax, becoming less numerous but of the same length towards posterior part of abdomen or even absent on last

three abdominal segments; absent in median areas of whole dorsum.

Pores (Fig. E): Multilocular derm pores circular, 13,2 (11,9 - 14,8) in diameter; variation in diameter similar over entire body; with 13 to 18 microloculi in an outer circle and 5 to 10 macroloculi in inner circle and with or without a central loculus; dispersed irregularly only from metathorax, their numbers becoming more numerous towards posterior end of abdomen; density in median and marginal areas the same.

VENTRAL SURFACE

Long setae (Fig. F): 453,4 (379,6 - 487,0) long; thin and hairlike; all areas of body as densely covered as dorsum except on narrow area between median and marginal areas of abdomen where they are less numerous or absent; evenly distributed over whole surface of each abdominal segment.

Short setae (Fig. G): 88,2 (71,3 -123,1) long; rigid; occurring in low numbers amongst the long setae in marginal areas of whole ventral surface; more numerous in median area of abdomen.

Medium setae: Vary in length between short and long setae; distributed amongst the long setae on whole ventral surface in median and marginal areas.

Spines (Fig. H): Bluntly pointed; 32,6 (26,2 - 43,8) long on anterior part of body; occurring in low numbers in marginal areas of thorax, becoming less numerous but of the same length towards posterior end of abdomen or even absent on last three abdominal segments; in median areas occurring from metathorax, becoming slightly more numerous towards

posterior end of abdomen. Denser in median areas than in marginal areas. Absent on narrow area between median and marginal areas of abdomen.

Pores (Fig. I): Multilocular derm pores circular, 13,2 (11,9 - 14,8) in diameter; variation in diameter similar over entire body; with 13 to 18 microloculi in an outer circle and 5 to 10 macroloculi in inner circle and with or without a central loculus; dispersed irregularly only from metathorax, their numbers becoming more numerous towards posterior end of abdomen; density in median and marginal areas the same.

Antennae (Fig. J): 8 segmented; 729,3 (612,0 - 842,6) long. Segment I 1½ times as wide as long, with one long seta on inner side and dorsally with 4 to 7 minute setae grouped together. Segment II as long as segment III, with 5 to 9 long setae and 4 to 5 small sensory pores at distal end. Segments III - VII all of about the same length but diminishing gradually in width; each with variable numbers of long hairlike setae (79,7 ; 50,5 - 95,2) and short (21,3 ; 16,4 - 23,8) bluntly pointed, fleshy setae and in some cases also with short, sharply pointed setae distributed around distal end of each segment. Segment VIII longer and narrower than segment VII, rounded at apex with 2 to 4 long hairlike setae (97,1 ; 71,7 - 137,9), 5 to 9 shorter setae and 7 to 13 short, fleshy setae (24,3 ; 21,4 - 28,6) placed apically.

Antennal segment	Length	Width
I	136,5 (110,2 - 179,5)	209,9 (188,8 - 250,0)
II	57,8 (47,9 - 69,5)	156,5 (131,9 - 193,8)
III	72,2 (51,9 - 90,7)	165,5 (146,4 - 200,2)
IV	95,5 (69,8 - 133,1)	155,6 (136,0 - 181,9)
V	97,1 (87,4 - 111,2)	135,4 (118,6 - 160,7)
VI	93,8 (59,8 - 111,9)	122,6 (109,3 - 139,8)
VII	99,2 (83,3 - 112,9)	111,7 (100,0 - 138,1)
VIII	129,0 (112,1 - 144,0)	89,4 (77,4 - 107,1)

Front legs much larger than middle and hind legs. Coxa with sclerotized apodeme; with long and short setae. Trochanter with long and short setae as well as sensory pores. Femur 815,5 (640,7 - 1029,3) long; 775,2 (634,3 - 978,4) wide with long setae (278,9 ; 194,0 - 340,7) on ventral side and short setae on posterior and anterior sides; dorsal side almost completely bare. Tibia short, with 9 to 11 long setae and 2 to 4 minute setae on posterior side; 10 to 18 long setae and 2 to 5 minute setae on anterior side. Tarsus with 3 to 6 long setae on both posterior and anterior sides; with 4 dorsal pores grouped together proximally. Claw slightly curved; smooth on inner surface; heavily sclerotized except basally; with 2 long seta-like digitules on each of posterior and anterior sides.

Middle and hind legs (Fig. K): Both pairs similar in size and shape. Coxa twice as wide as long with sclerotized apodeme; 5 to 9 long setae on ventral side; 9 to 15 short setae on posterior side and 8 to 14 on anterior side. Trochanter with 5 to 9 long setae on ventral side; 1 to 3 minute setae, 0 to 4 long setae and 7 to 10 sensory pores on posterior side; 1 to 4 minute setae, 1 to 5 long setae and 5 to 12 sensory pores on anterior side. Femur 358,4 (277,8 - 444,4)

long; 270,7 (225,9 - 313,0) wide with long ventral setae (181,6 ; 139,8 - 237,0) and short rigid setae on posterior and anterior sides. Tibia 183,8 (152,8 - 214,8) long; 133,9 (107,4 - 154,6) wide with 4 to 6 long ventral setae (148,8 ; 109,3 - 199,1); 4 to 8 long setae and 4 to 7 minute setae on posterior side; 4 to 8 long setae and 3 to 6 minute setae on anterior side. Tarsus with 2 long ventral setae; 2 to 3 long setae on posterior side and 2 on anterior side; 3 dorsal pores grouped together proximally. Claw 221,6 (185,2 - 272,2) long; 35,7 (23,1 - 43,5) wide; slightly curved; smooth on inner surface; heavily sclerotized except basally; with one long seta-like digitule on each of posterior and anterior sides.

Thoracic spiracles: Two pairs of thoracic spiracles with circular or elongated openings; 3 to 4 small pores next to opening on posterior side. Atrium 158,9 (125,0 - 197,2) in diameter; with 11 to 18 large multilocular pores arranged in one or two circles on the peritreme wall, just inwards to the atrium; 18 to 30 simple pores.

Abdominal spiracles: Seven pairs; the first 2 pairs are slightly smaller than thoracic spiracles; spiracles becoming smaller towards posterior part of abdomen; first pair situated more marginally. Atrium of first two pairs 142,5 (112,0 - 171,3) in diameter; with 11 to 18 multilocular pores arranged in one or two circles on the peritreme wall, just inwards to the atrium; 11 to 30 simple pores.

Mouthparts: True mouthparts absent. Folds occur in the body at the place where mouthparts occur in other stages.

Genital opening: A transverse fissure situated anteriorly

near anus with distinct lips; with or without setae.

Anal opening: Circular or oval; sclerotized; situated apically or sub-apically on ventral surface in middle of small naked area.

MALE

Males were not seen and biological studies (par. 6) indicated that the species is parthenogenetic.

MATERIAL EXAMINED

South Africa, Vredendal, February 1975, at roots of vines, C.A. de Klerk, collection no. MD 3. Described from a female holotype (MD 3/1) and 9 female paratypes (OVRI). In addition to the type-series the following material was studied. Vredendal, December 1976, on roots of vines, C.A. de Klerk, collection no. MD 4, 5 cysts (OVRI); Vredendal, March 1977, obtained in laboratory, C.A. de Klerk, collection no. MD 27, 6 first instar larvae (OVRI).

NOTES

The species closely resembles M. prieskaensis (Jakubski) from which if differs mainly by the absence of bulbous spines.

PLATES AND LETTERING

Plate 17: Margarodes vredendalensis sp. n., nymph of the cyst stage (with labium shown to one side)

Plate 18: Margarodes vredendalensis sp. n., adult female

A = dorsal and ventral sides of body

B = dorsal long seta

C = dorsal short seta

D = dorsal long spine

E = dorsal multilocular derm pore

F = ventral long seta

G = ventral short seta

H = ventral long seta

I = ventral multilocular derm pore

J = antenna

K = hind leg

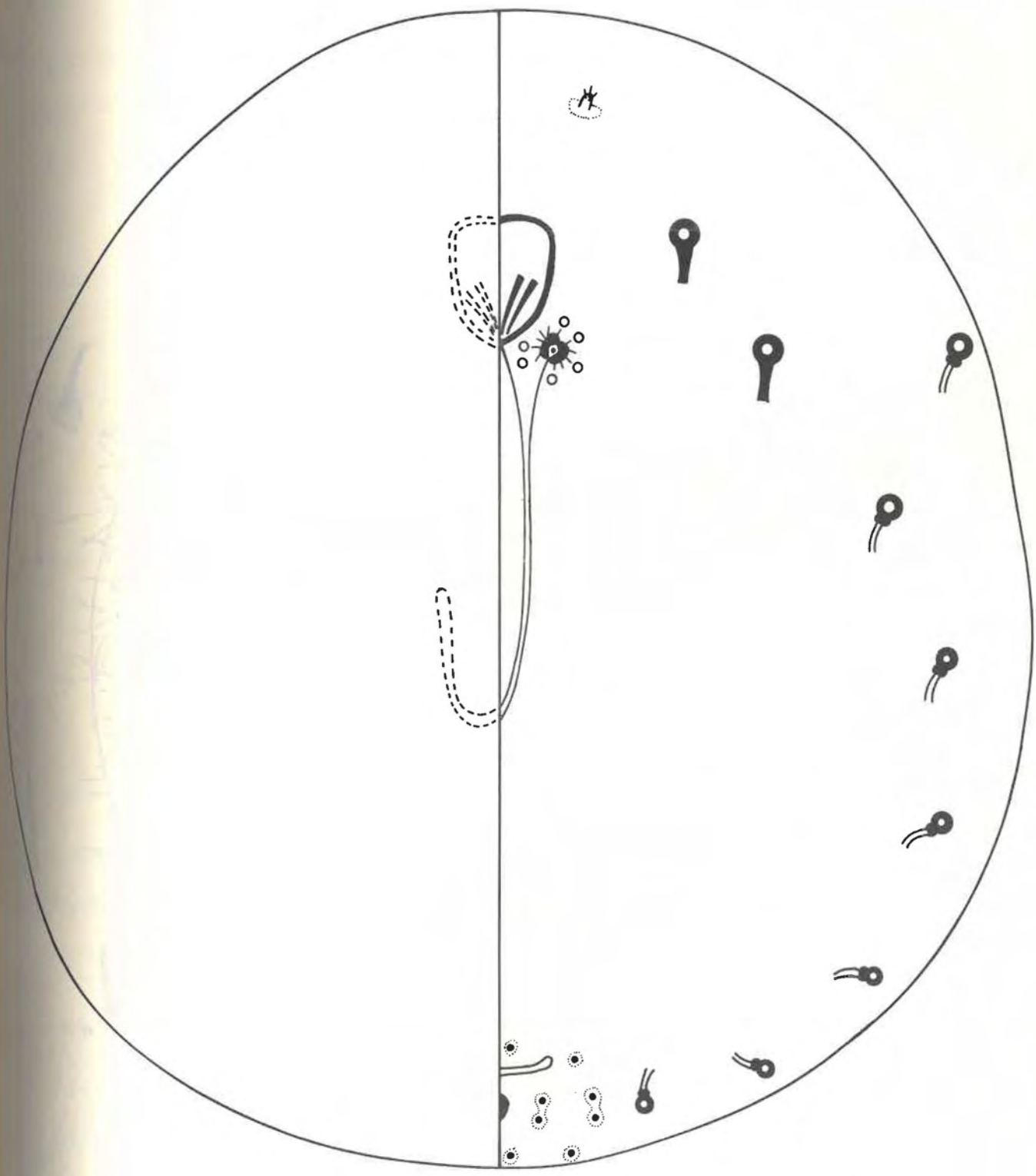

PLATE 17

PLATE 18

3. DISTRIBUTION OF MARGARODES SPECIES IN SOUTH AFRICA

Ten species of Margarodes are presently known from South Africa, five of which are of economic importance in the cultivation of vines. The distribution of the various species will be discussed separately.

MARGARODES PILOSUS (JAKUBSKI).

This species was first described from a single female with the following inscription on the slide "in ground with locust egg-pods, C.P.L., May 1917, Paardeberg, O.F.S." No live material was found by the author.

MARGARODES NEWSTEADI BRAIN.

According to Brain (1915) the cysts of this species were found at the roots of grass in Pretoria. No live material was found by the author.

MARGARODES PERINGUEYI BRAIN.

They occur commonly in the Pretoria area (Brain, 1915). Brain found the cysts at roots of grass in the field and in lawns. No live material was found by the author.

MARGARODES RUBER BRAIN.

Brain (1915) found this species in Pretoria on roots of grass and in association with M. peringueyi. No live material was found by the author.

MARGARODES UPINGTONENSIS SP.N.

The cysts were found on roots of kikuju grass in Upington in the North Western Cape. In patches where the lawn was dying,

the population was very high.

MARGARODES GREENI BRAIN.

According to Brain (1915) it was first found during October 1914 on the roots of vines at Elsenburg near Stellenbosch.

A survey was made during 1975 by the Division of Plant and Seed Control to determine the occurrence of Agrobacterium tumefaciens (crown gall) in vine nurseries of the Western and North Western Cape Province. This provided the opportunity to investigate soil samples for the presence of Margarodes. Only nurseries with Richter 99 as rootstock were investigated. A total of 317 samples from 148 farms were investigated and 16,9 per cent of these farms were found to be infested with M. greeni. It occurred in all the major vine producing areas. As only soil was investigated, it is uncertain if the vines were actually attacked.

The species has recently been found to attack and kill vines near Worcester and Robertson as well as in the Olifants River irrigation area near Vredendal and Lutzville. It has also been found to kill kikuju grass at Groot Drakenstein in the Paarl area. During 1975 a very high population was found in an apple orchard in the Piketberg area. Some of the trees were dead entirely, while others showed a decline in growth with some of the branches dying.

The distribution of M. greeni in the vineyard areas of South Africa is shown in Figure 3.1.

MARGARODES TRIMENI GIARD.

According to Jakubski (1965) cysts were found free in the

soil and on roots of grass in the regions of Ceres, Tulbagh, Riversdale and Pretoria. M. trimeni was recently found in a vineyard in the Windmeul area near Paarl as well as in the Slanghoek area near Worcester. The vines in the Slanghoek area were dying in patches and cysts were found loose in the soil as well as on the roots with their stylets inserted. The distribution of this species is shown in Figure 3.1.

MARGARODES PRIESKAENSIS (JAKUBSKI)

This species was described from females found during 1946, 1953 and 1958 in vineyards near Prieska and Kakamas in the Orange River irrigation area in the Northern Cape (Jakubski, 1965). According to Du Toit (personal communication) it has also been found to attack and kill vines in the same area near Upington and Groblershoop. The infestation occurred in vineyards consisting of about 82 000 vines. Recently M. prieskaensis was also found in a vineyard near Hopetown. The distribution of this species is shown in Figure 3.2.

MARGARODES VREDENDALENSIS SP.N.

The species has been known from before 1964 to attack vines in the Olifants River irrigation area in the North Western Cape Province (Burger, 1970). Recently it was found in 9 vineyards in the same area near Vredendal and Lutzville. In each vineyard the vines were dying in patches. Figure 3.2 shows the distribution of this species.

MARGARODES CAPENSIS (GIARD)

According to Brain (1915) the species was found between 1896 and 1904 at the roots of vines in the Worcester, Malmesbury and Stellenbosch areas.

In a recent survey to determine the occurrence of M. capensis in the Malmesbury area, 40 farms were investigated and it was found that 32,5 per cent of these were infested. The infested vineyards comprised of approximately 200 000 vines, covering 85,86 ha. The majority of infested vineyards occurred in the Paardeberg area. It was also found on the roots of steenboksuring (Rumex angiocarpus, fam. Polygonaceae), an exotic weed which occurs very commonly in vineyards in this area. The distribution of this species in the wine producing areas of South Africa is shown in Figure 3.2.

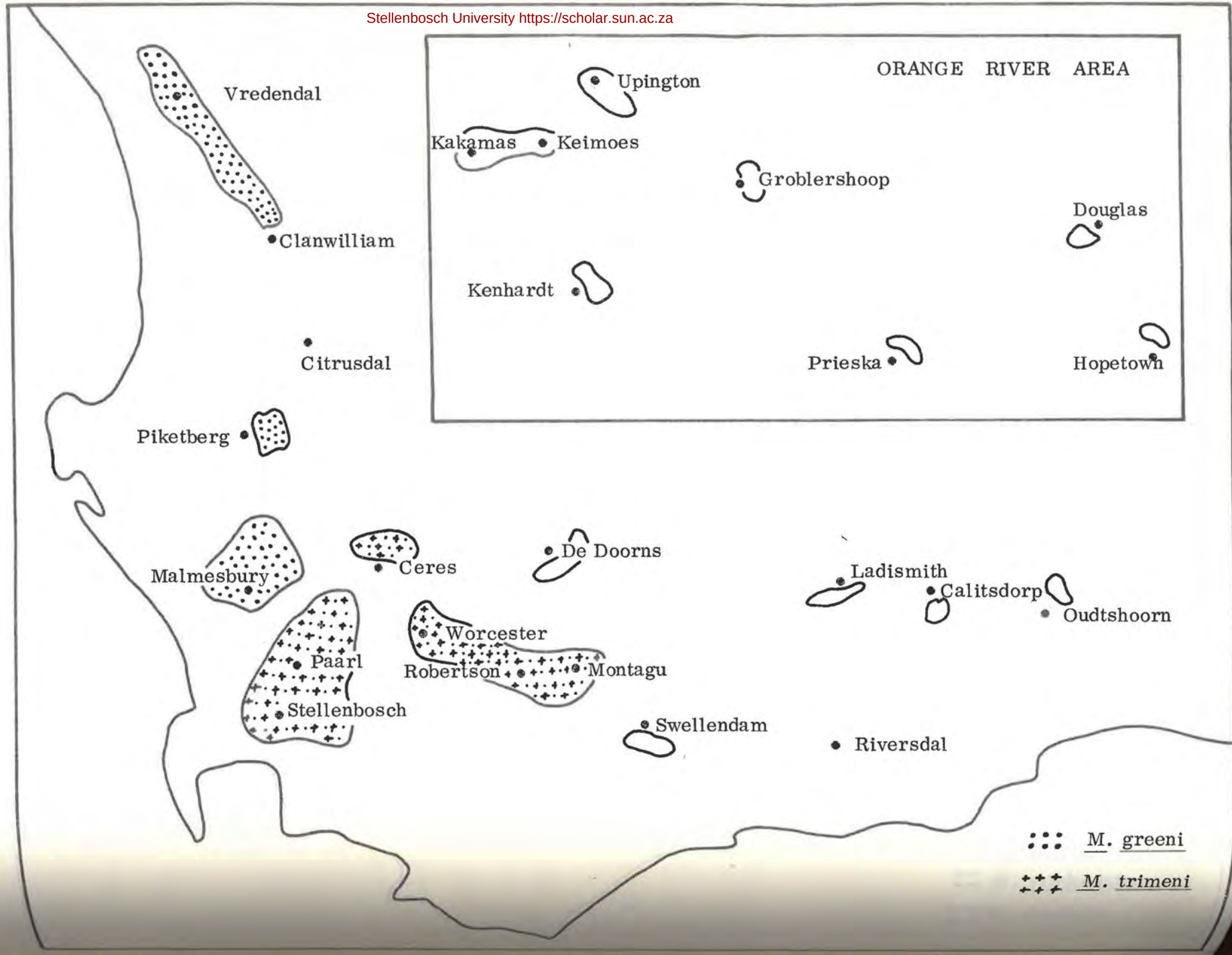

fig. 3.1 : DISTRIBUTION OF MARGARODES GREENI AND M. TRIMENI IN THE MAJOR VINE GROWING AREAS OF SOUTH AFRICA.

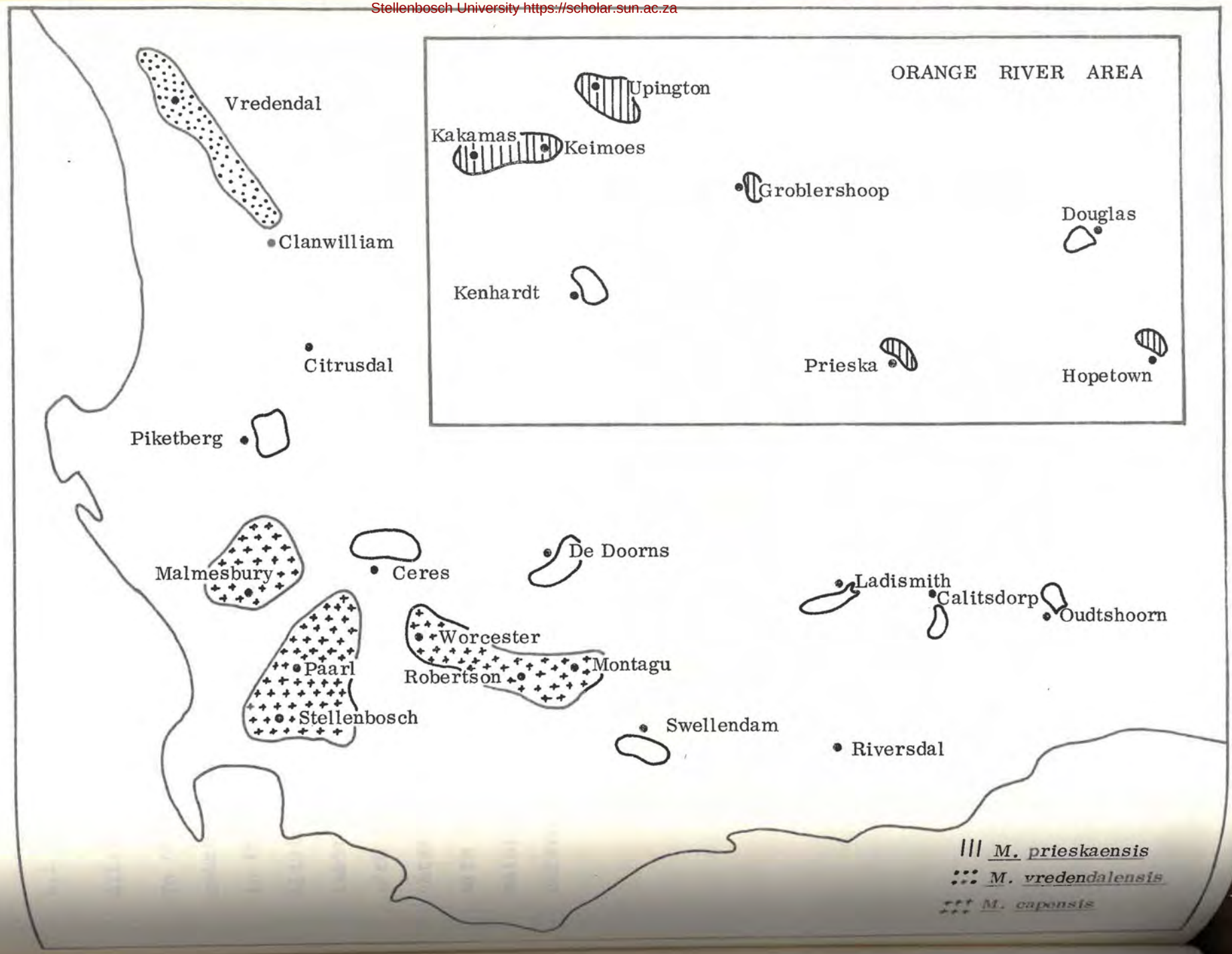

Fig. 3.2 : DISTRIBUTION OF MARGARODES PRIESKAENSIS, M. VREDENDALENSIS AND M. CAPENSIS IN THE MAJOR VINE GROWING AREAS OF SOUTH AFRICA.

4. BIOLOGY OF MARGARODES CAPENSIS UNDER LABORATORY AND CONTROLLED CONDITIONS

4.1 MATERIAL AND METHODS

4.1.1 EMERGENCE OF ADULT FEMALES FROM CYSTS

To obtain cysts for laboratory observations, soil samples were taken at different vines and on various dates (as mentioned in the results) in a heavily infested vineyard on the farm Klipfontein in the Paardeberg area near Malmesbury. In the laboratory the soil was washed with water through three sieves with apertures of 2,8; 2,0 and 1,0 mm respectively. The cysts obtained in each sieve were removed and separated from those with an emergence orifice (empty cysts) (Fig. 4.1). The remaining cysts from each sieve were subjected to a test to determine if they contained live nymphs.

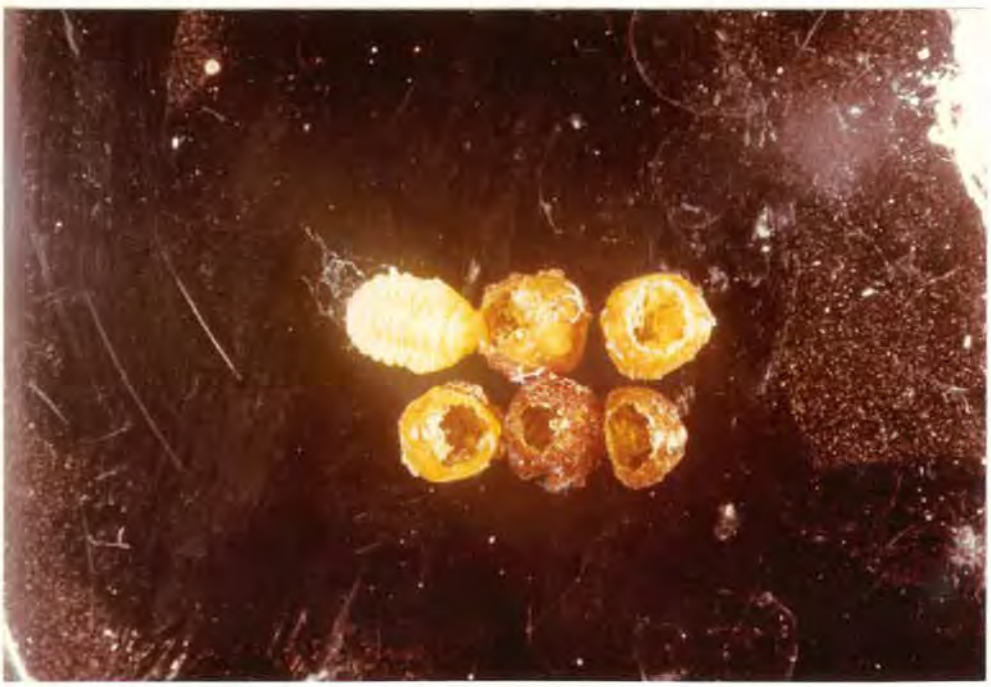

Fig. 4.1 : Cysts of M. capensis with an emergence orifice (empty cysts) and adult female after emergence.

The cysts were placed in water, assuming that those that sink to the bottom would contain live nymphs, while those with dead nymphs would float. The accuracy of this method was first tested with 50 cysts. After the cysts had been separated, each cyst was opened to determine whether the nymph was alive or not as indicated by the presence or absence of body fluid. Of the cysts that sank 90,9 per cent were alive and of those that floated, 82,4 per cent were dead. The experiment was repeated with 428 cysts and it was found that 98,5 per cent of those that sank were alive while 73,7 per cent of those that floated were dead. From these results it appears that live cysts can be separated from dead cysts, with only a 2 - 10 per cent error, by the fact that they sank in water.

Live cysts were placed on moist filter paper in plastic petri dishes (8,5 cm in diameter and 1,5 cm deep) of which the lids were punctured with small holes. The dishes were kept in the laboratory at room temperature and humidity, unless otherwise mentioned. Observations were made daily and each female was removed on emergence. Cysts used for observations were of all three size ranges unless otherwise mentioned.

4.1.2 OVIPOSITION

Cysts were collected and kept in the laboratory as described in paragraph 4.1.1. On emergence during January and February, thirty females were placed individually on moist filter paper in petri dishes and observed daily. The females were kept in the laboratory at temperatures ranging from 22 to 30°C. After commencement of oviposition each female was removed daily to another dish and the number of eggs was counted.

To determine the influence of temperature on various aspects of oviposition (mentioned in the results), six females were placed individually in petri dishes in a desiccator. Females were used directly after emergence from cysts and as their size have an influence on the number of eggs produced (par. 4.3.5), only females with approximately the same size were selected for all treatments. One desiccator was kept at each of 10, 25, 30 and 40°C. The relative humidity in each desiccator was kept constant with a saturated solution of sodium chloride. The relative humidity varied between desiccators from 75,0 to 76,5 per cent depending on the specific temperature (Winston & Bates, 1960).

After egg laying the dishes were removed from the desiccator and the total number of eggs per female was determined. As the eggs were covered with wax threads, they were very difficult to observe. To facilitate counting, the wax was dissolved with xylene.

The influence of relative humidity on oviposition was tested at two different percentages at 25°C. Relative humidities of 32,5 and 75,5 per cent were obtained by saturated solutions of magnesium chloride and sodium chloride respectively (Winston *et al*. 1960). The rest of the procedures followed, were similar to those applied to determine the influence of temperature on oviposition.

The procedures to determine the influence of soil moisture on oviposition were as follows. Small glass tubes (2 cm in diameter and 6 cm deep) were filled with 25 g air-dried soil. The percentage moisture of the soil was determined on a dry - mass basis as described by Gardner (1965). The soil in four

of the tubes was kept dry (2% soil moisture) while the moisture of sixteen tubes was increased by adding 1, 2, 3, 5 and 7 cc water respectively to four tubes each. Directly afterwards, females of approximately the same size were placed individually in each tube and the container with soil, water and the female was weighed. The tubes were kept for a period of one month at a constant temperature of 25°C. The original mass of each tube was kept constant by weighing and adding water every second or third day. After one month the total number of eggs per female was determined.

4.1.3 INCUBATION OF EGGS

To determine the influence of relative humidity on incubation, five embryonic watch glasses containing 50 one day old eggs each were placed in a desiccator. Three desiccators, each with a constant relative humidity of 32,5; 75,5 and 100 per cent, were kept at a constant temperature of 25°C. A relative humidity of 100 per cent was obtained by pure water while that of the other two humidities were obtained as described in paragraph 4.1.2.

The containers were observed after certain periods, as shown in the results and at each observation date the number of larvae and live eggs were counted. The intervals between observations were kept relatively long in order to reduce disturbance of the eggs and conditions in the desiccators. Larvae were removed during each observation.

The influence of temperature on the incubation of eggs was tested at 40, 30, 25 and 10°C at a constant relative humidity of 100 per cent. The same methods were applied as that de-

scribed to determine the influence of relative humidity.

To determine the influence of soil moisture on incubation, fifteen eggs were placed in an embryonic watch glass and covered with 6 g air-dried soil. The moisture content of the soil was determined on a dry-mass basis as described by Gardner (1965). The soil in four of the containers was kept dry (2% soil moisture) while the moisture of sixteen containers was increased by adding 0,5; 1,0; 1,5 and 2,0 cc water respectively to four containers each. Each container was weighed and kept at a constant temperature of 25°C. The original mass of each container was kept constant by replacing evaporated water every second or third day. At each observation, as shown in the results, the containers were covered with a small glass plate and turned upside down under the microscope. The number of dead as well as live eggs in each container were counted. On hatching from eggs, larvae burrowed into the soil and could not be observed. Their number was determined by subtracting the total number of live and dead eggs from the original number of eggs.

The same methods were applied to determine the influence of different temperatures at a constant percentage soil moisture. Five containers with 15 eggs each, were used.

4.1.4 DEVELOPMENT OF FIRST INSTAR LARVAE TO ADULT FEMALES

To determine the time of development of first instar larvae to cysts, procedures were as follows. Small one bud cuttings of ungrafted Steen were planted in sterilized soil. After the root system had developed sufficiently, the vines were uprooted and the roots washed with water and sterilized

with 5 per cent hypochloride. The stem of each vine was placed in a hole on the side of a sterilized, plastic petri dish (8,5 cm in diameter and 1,5 cm deep) so that the vine was in a horisontal position with the roots on the inside and the leaves on the outside of the dish. Most of the roots were then covered with a layer of moist filter paper while two or three rootlets were arranged on the surface of the paper. On hatching from the eggs, larvae were placed on these uncovered roots. The dishes were covered with dark lids and kept at 25°C. The filter paper was moistened once a week and the vines could be kept alive for three months. The larvae were investigated daily with the aid of a microscope and changes in their development were noted.

To determine the time of development of cysts to adult females, procedures were as follows. During August 1975, 48 ungrafted cuttings of the cultivar Steen were planted in sterilized soil in plastic bags, 30 cm wide and 45 cm high. Each vine was infested with five adult females directly after their emergence from cysts in the laboratory during January 1976. From May 1976 to April 1977, two bags were investigated monthly for the presence of cysts. The roots were microscopically investigated and the soil was washed with water through sieves with apertures of 2,8; 2,0 and 1,0 mm respectively. The same experiment was repeated and observations were made from May 1977 to April 1978.

4.2 EMERGENCE OF ADULT FEMALES FROM CYSTS

4.2.1 TIME OF EMERGENCE

Cysts were collected monthly at the vineyard in Malmesbury

from October 1974 to September 1975 and observed in the laboratory as described in paragraph 4.1.1. From a total 4 393 live cysts collected during this period, 200 females emerged from 25 November 1975 to 1 March 1976. During November and December the numbers of females were very low, but after the first week of January their numbers increased rapidly, reaching a peak at the end of the third week. During the last week of January and the first two weeks of February the number of emerging females decreased again rapidly. During the rest of February to the beginning of March their numbers were very low (Fig. 4.2).

The remaining cysts that did not develop into females were kept in the laboratory and a total of 131 females emerged from 17 December 1976 until 3 March 1977. During December and January their numbers were low. From the beginning of February it increased rapidly, reaching a peak almost at the middle of February. During the third week of February their numbers decreased suddenly and at the end of February and the beginning of March the emergence of females was low (Fig. 4.2).

From the preceding results it is clear that females could emerge from cysts kept in the laboratory as from the end of November to the beginning of March. Emergence of females could be at its highest during the third week of January or at the middle of February. As mentioned in paragraph 5.2.3 females occurred under field conditions from December to May with a peak during February and March. According to Gonzáles *et al*. (1969) females of *Margarodes vitis* emerge under field conditions from the end of October to the end of December

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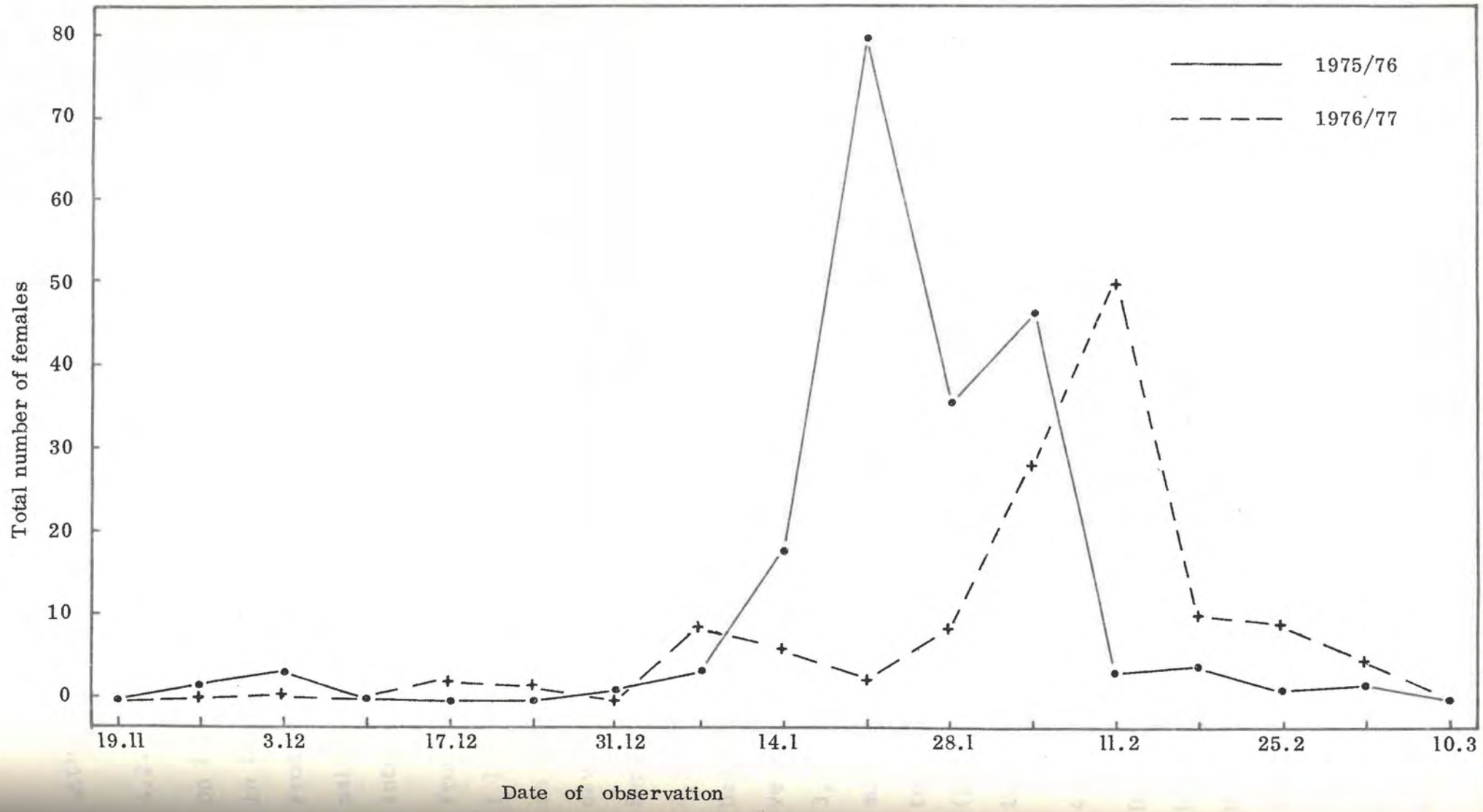
FIG. 4.2 : TOTAL NUMBER OF ADULT FEMALES EMERGED FROM CYSTS OF M. CAPENSIS ON VARIOUS DATES DURING 1975/76 AND 1976/77 UNDER LABORATORY CONDITIONS.



with a peak of emergence at the end of November.

4.2.2 PERCENTAGE EMERGENCE

On 15 January 1974 a total of 428 live cysts were collected in the vineyard at Malmesbury and observed in the laboratory. From 21 January to 15 February 1974, a total of 39 adult females emerged. Thus 9,11 per cent of the cysts developed into females during one season.

From October to the beginning of January 1975 a total of 1 116 live cysts were collected in the same vineyard and kept in the laboratory. Of this population only 4,93 per cent developed into adult females during 1975. From February to September 1975 a further 3 277 cysts were collected of which 4,55 per cent developed into females during 1976. During December 1976 a total of 4 741 cysts were collected and investigated under laboratory conditions. Of this number only 3,16 per cent developed into females during 1977. These results show that only a small percentage of cysts develop into adult females annually. According to González et al. (1969) the annual emergence of females of Margarodes vitis is also very low, varying between 2,4 and 10 per cent.

4.2.3 EMERGENCE DURING SUCCESSIVE YEARS

During August 1973 a total number of 62 live cysts - presumably of different ages - were collected in the vineyard at Malmesbury and observed in the laboratory for a number of years. During January and February of 1974, 1975, 1976 and 1977 the percentage emergence of adult females from the original number of cysts, was 8,06; 16,13; 3,23 and 3,23 respectively. Of the original number of cysts, 19,36 per

cent were still alive after four years.

The 1 116 live cysts referred to in paragraph 4.2.2, were observed in the laboratory over successive years. Where 4,93 per cent adult females emerged during 1975 as reported above, 7,17 and 2,98 per cent emerged during 1976 and 1977 respectively. Of the original number of cysts, 12,81 per cent was still alive at the end of the third year.

These results show clearly that females could emerge during three or four successive years from a collection of cysts, even if the cysts are detatched from their host plant and do not feed. It follows that if an infested vineyard is replanted within three to four years, the new vineyard could thus still become infested from cysts that had developed on the original planting.

4.2.4 PERCENTAGE EMERGENCE OF FEMALES FROM CYSTS OF DIFFERENT SIZES

Cysts were collected monthly from September 1974 to the beginning of January 1975. Cysts of each size range viz. greater than 2,8; 2,8 - 2,0 and 2,0 - 1,0 mm in diameter were observed separately in the laboratory until June 1975 and the emergence of females during January and February was noted. The number of cysts of each size range and at each date of collection as well as the number of females that had emerged from them, are given in Table 4.1.

Table 4.1 : Emergence of M. capensis females from cysts of various sizes (diameter) collected monthly from October 1974 to January 1975.

	Greater than 2,8 mm		2,8 - 2,0 mm		2,0 - 1,0 mm	
Date Collected	Cysts	Females	Cysts	Females	Cysts	Females
22-10-74	241	11	103	1	62	0
18-11-74	102	7	28	1	14	0
17-12-74	115	6	69	3	35	2
06-01-75	207	18	78	6	62	0
Total	665	42	278	11	173	2
Percentage		6,32		3,96		1,16

The results show that the emergence is more frequent among cysts of a greater size (greater than 2,8 mm), but that females could also emerge from small cysts (2,0 - 1,0 mm). The age of the cyst-stage can thus not be determined by the size of the cyst-body.

These results were confirmed by the emergence of females during 1976 from a total number of 4 393 cysts mentioned in paragraph 4.2.1 which were collected monthly from October 1974 to September 1975. The percentage emergence of females from cysts in the size range greater than 2,8 mm was 6,51. The percentage emergence from cysts in the size ranges 2,8 - 2,0 and 2,0 - 1,0 mm was 2,40 and 0,15 respectively.

4.2.5 INFLUENCE OF TEMPERATURE AT A CONSTANT RELATIVE HUMIDITY

Cysts were collected from the vineyard at Malmesbury during

October 1976 and four dishes with 50 of these live cysts each, all larger than 2,8 mm in diameter, were placed in a desiccator. One desiccator was placed at each of the following temperatures (1) 40°C constant (2) 30°C constant (3) 25°C constant (4) 10°C constant (5) 25°C constant during the day and 20°C during the night (6) alternately at a constant temperature of 30°C for five days and then at 10°C for two days (7) room temperature. The relative humidity in each desiccator was kept constant with a saturated solution of sodium chloride. The percentage humidity varied between desiccators from 75,0 to 76,5 depending on the specific temperature (Winston et al. 1960). The cysts were kept under these conditions from October 1976 until May 1977. The number of females that emerged at each temperature is shown in the following table.

Table 4.2 : Number of M. capensis females emerged from cysts (50 per replicate) kept at various temperatures and at a constant relative humidity.

Replicate	40°C	30°C	25°C	10°C	25:20°C	30:10°C	Room temp.
1	0	2	2	0	4	2	4
2	0	2	1	0	3	1	3
3	0	2	7	0	7	5	3
4	0	1	3	0	2	2	4
Total	0	7	13	0	16	10	14

As indicated in Table 2, temperatures of 40 and 10°C were evidently too high and too low respectively for the emergence of females. With an analysis of variance no evidence could be found that the other treatments differed statistically from each other (F=1,0302). In all the treatments females emerged

from January to March. The time of emergence of females was thus not influenced by different moderate temperatures and the dormancy of cysts could not be broken by the constant or varying temperatures tested. According to González et al. (1969) the dormancy of cysts of M. vitis could be broken by certain temperatures and the best results were obtained by a constant 28°C as well as 30°C for 3 or 5 weeks followed by a constant temperature of 26°C.

At the end of April 1977 the cysts were opened to determine if they were alive or dead. The number of dead cysts per treatment is given in Table 4.3.

Table 4.3 : Number of dead cysts (out of 50 per replicate) after six months at various temperatures and at a constant relative humidity.

Replicate	40°C	30°C	25°C	10°C	25:20°C	30:10°C	Room temp.
1	50	13	7	10	12	6	19
2	50	5	13	6	16	8	9
3	50	17	14	8	7	12	10
4	50	12	12	9	12	12	7
Total	200	47	46	33	47	38	45

The results show clearly that cysts are killed at a temperature of 40°C. The result of an analysis of variance to indicate any differences between the other treatments, were negative (F=0,5751). The absence of adult females at a temperature of 40°C was thus as a result of all the cysts being killed. However, the low temperature of 10°C did not kill the cysts but nevertheless inhibited the emergence of females.

4.3 OVIPOSITION AND FECUNDITY

4.3.1 PRE-OVIPOSITION PERIOD

Under laboratory conditions the females were very active during two to four days after emergence, moving around and trying to burrow through the filter paper placed in the petri dishes. On reaching the edge, most of the females crawled underneath the paper. After this period of activity they become sedentary and only little movements of the legs and abdomen were noticed. During the inactive period wax threads were excreted, first on the dorsal and ventral sides of the last abdominal segment, but two to three days later on all the abdominal segments. During oviposition these wax threads became longer and more dense to cover the whole body as well as the eggs (Fig. 4.3).

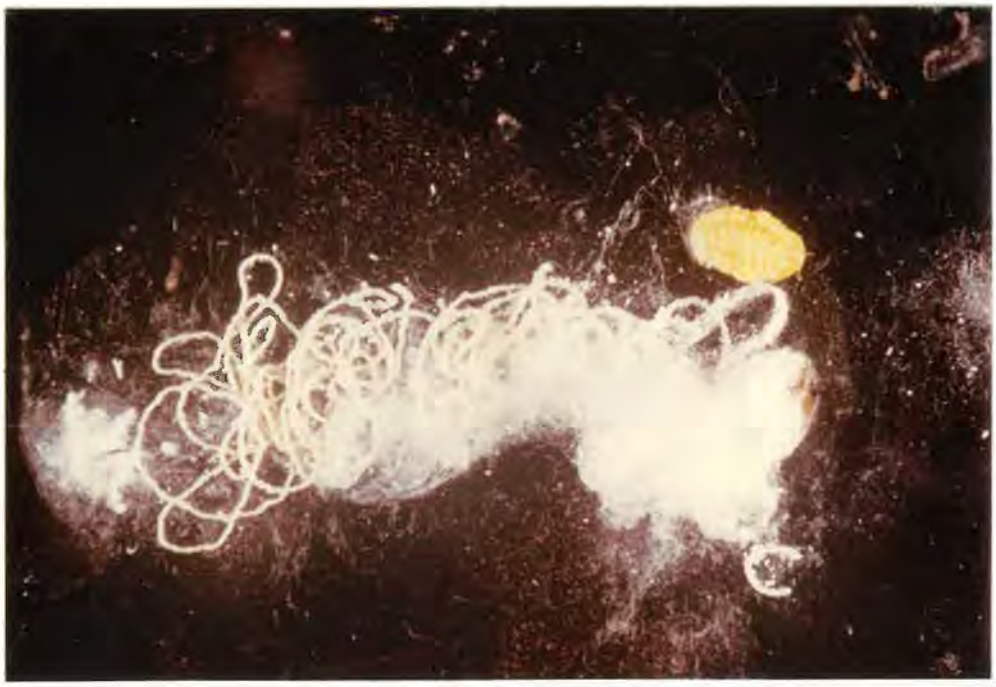


Fig. 4.3 : Adult female of M. capensis before oviposition with dorsal side up (top) and at end of oviposition period with eggs and body covered with wax threads (bottom).

The average period from emergence to the first appearance of wax threads was 6 days with a minimum and maximum of 3 and 11 days respectively. The average period of wax production before oviposition started, was 3 days with a minimum of one day and a maximum of 6 days. The pre-oviposition period thus lasted 9 days on average with a minimum and maximum of 4 and 15 days respectively (Table 4.4).

It was investigated whether the females migrated to the soil surface during their pre-oviposition period. Glass jars, 6 cm high and 4 cm in diameter, were filled with moist soil and 50 females were placed individually on the soil surface in each container directly after emergence from the cysts. All of them burrowed immediately into the soil. Seven returned to the soil surface the following day and crawled around for one or two hours before burrowing back into the soil. Two of the females returned to the surface during two successive days. After a month the soil was removed and all the females were found at the bottom of the container. Eggs had been produced by every female and in six containers a total of 110 larvae were found.

These results indicate that females would not migrate to the soil surface after emergence. This is probably because they reproduce parthenogenetically and need not come to the surface for mating as is the case with Margarodes prieskaensis (Du Toit, 1975). The reappearance of some of the females on the soil surface was possibly only by chance, due to the small container in which the possibility for natural migration through the soil was limited.

4.3.2 OVIPOSITION PERIOD AND LONGEVITY OF FEMALES

As shown in Table 4.4 the average period of oviposition was 11 days with a minimum and maximum of 5 and 18 days respectively. The period from the end of oviposition to the death of the females lasted an average of 4 days with a minimum and maximum duration of 2 and 11 days respectively. The average lifespan of the females after emergence from the cyst was 24 days with a minimum and maximum of 15 days and 32 days respectively (Table 4.4).

4.3.3 FECUNDITY

When the female oviposits in soil, the eggs are laid in a bundle and covered with wax threads to form a compact egg packet. When the female oviposits in an open space, however, the eggs are laid attached to one another in the form of a string, covered with wax threads. Up to 67 eggs were counted in a single string. The number of eggs per female averaged 251 with a minimum and maximum of 33 and 539 respectively (Table 4.4).

4.3.4 RATE OF OVIPOSITION

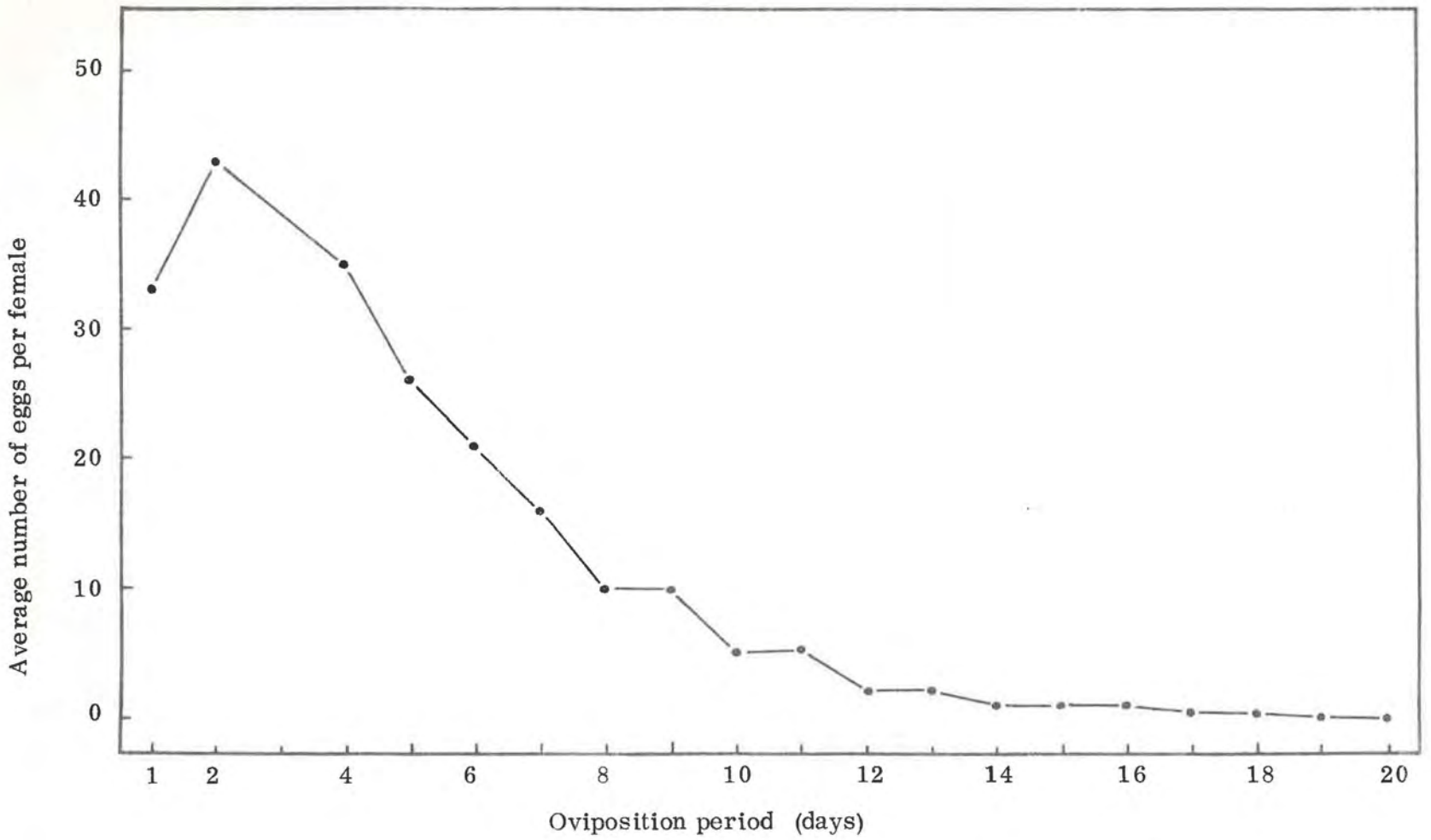
The lowest egg production per female per day varied between 1 and 18 with an average of 4. The maximum varied between 8 and 122 with an average of 61. The average egg production per female per day varied between 4 and 55 with an average of 23 (Table 4.4).

The total number of eggs per female per day for 30 females was determined and the average for each day during the oviposition period is shown in Figure 4.4. On the first day of

TABLE 4.4 : PRE-OVIPOSITION PERIOD, OVIPOSITION PERIOD, LONGEVITY, TOTAL NUMBER OF EGGS PER FEMALE AND NUMBER OF EGGS PER FEMALE PER DAY OF MARGARODES CAPENSIS UNDER LABORATORY CONDITIONS.

Replicates	Duration from emergence to formation of wax threads (days)	Duration from formation of wax threads to commencement of oviposition (days)	Duration from emergence to commencement of oviposition (days)	Oviposition period (days)	Duration after egg laying until death of female (days)	Longevity of adult female (days)	Total number of eggs per female	Minimum number of eggs per female per day	Average number of eggs per female per day	Maximum number o eggs per female per day
1.	3	2	5	11	3	19	344	3	31	86
2.	3	1	4	14	4	22	300	2	21	56
3.	8	3	11	6	3	20	60	6	10	16
4.	3	6	9	16	3	28	96	4	6	18
5.	7	6	13	13	3	29	92	1	7	23
6.	11	3	14	9	5	28	38	1	4	13
7.	6	3	9	11	5	25	267	5	24	122
8.	4	2	6	11	3	20	390	9	35	79
9.	8	5	13	15	3	31	71	1	5	19
10.	3	4	7	10	3	20	239	2	24	84
11.	9	1	10	8	2	20	33	1	4	8
12.	4	1	5	13	2	20	243	1	19	97
13.	8	2	10	11	3	24	345	8	31	65
14.	8	2	10	7	11	28	159	2	23	39
15.	9	3	12	6	6	24	97	2	16	29
16.	7	2	9	9	5	23	285	3	32	75
17.	6	2	8	15	2	25	488	5	33	86
18.	7	4	11	16	5	32	419	5	26	90
19.	10	5	15	15	2	32	173	1	12	38
20.	6	3	9	6	6	21	231	17	39	57
21.	7	2	9	18	2	29	165	1	9	32
22.	6	3	9	9	4	22	161	7	18	26
23.	5	1	6	16	3	25	351	1	22	72
24.	3	3	6	6	4	16	195	11	33	73
25.	5	2	7	6	5	18	197	4	33	90
26.	6	2	8	16	2	26	510	2	32	115
27.	7	2	9	11	3	23	477	6	43	89
28.	4	3	7	17	6	30	288	1	17	58
29.	5	2	7	14	2	24	110	3	16	98

FIG. 4.4 : AVERAGE NUMBER OF EGGS OVIPOSITED PER FEMALE PER DAY BY *M. CAPENSIS* UNDER LABORATORY CONDITIONS.



oviposition the average number of eggs per female was very high, reaching a peak on the second day. Afterwards the production of eggs decreased steadily to none on the nineteenth day; 62 per cent of the total production were laid during the first four days.

4.3.5 FECUNDITY WITH REGARD TO THE SIZE OF THE FEMALE

Twenty seven females were weighed individually on emergence from the cysts and the average number of eggs per female per day as well as the total number per female were determined in the laboratory as described. Body mass of females varied between 1,3 and 50,0 mg. The results were analysed statistically and the linear regression coëfficient determined. A highly significant ($P<0,01$) correlation was found between the body mass of females and the total number of eggs produced ($r=0,7722$). As shown in Figure 4.5A the total number of eggs per female increases with increasing body mass ($y=55,3 + 14,7x$). A highly significant ($P<0,01$) correlation was also found between the body mass of females and the average number of eggs per female per day ($r=0,8997$). As the body mass per female increases the average number of eggs per female per day also increases ($y=-0,10 + 1,07x$) (Fig. 4.5B).

4.3.6 INFLUENCE OF TEMPERATURE AT A CONSTANT RELATIVE HUMIDITY

Four desiccators each with a constant relative humidity of 75,5 per cent and containing six females, were kept individually at 10, 25, 30 and 40°C. After a period of one month the total number of eggs per female was determined and the results are shown in Table 4.5.

FIG. 4.5 : SCATTER DIAGRAM OF BODY MASS OF ADULT FEMALES OF M. CAPENSIS TO (A) TOTAL NUMBER OF EGGS OVIPOSITED PER FEMALE AND (B) AVERAGE NUMBER OF EGGS OVIPOSTED PER FEMALE PER DAY.

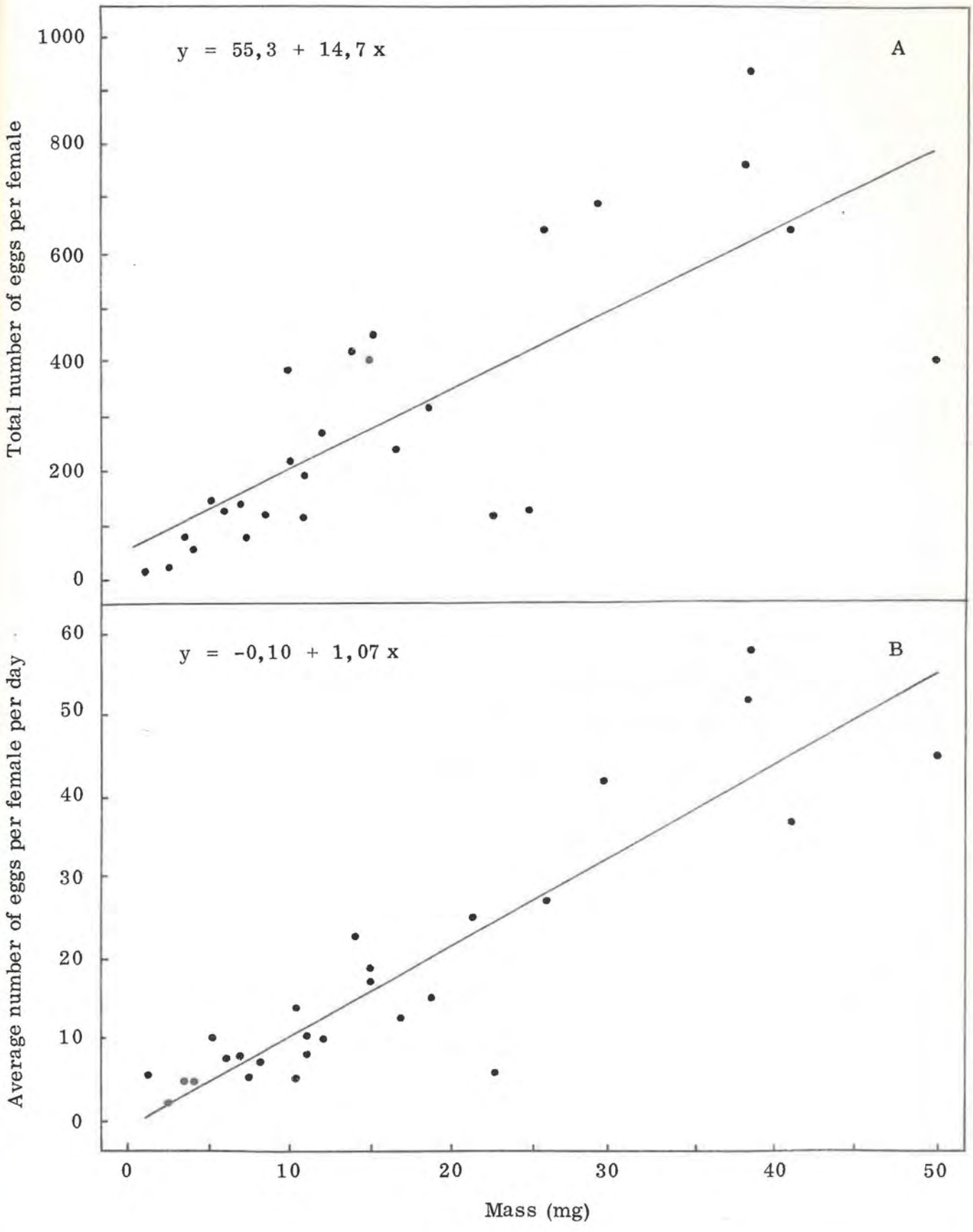


Table 4.5 : Total number of eggs oviposited per female of M. capensis at different temperatures and a constant relative humidity.

Replicate	Temperature 10°C	25°C	30°C	40°C
1	0	134	-	0
2	0	360	-	0
3	0	78	-	0
4	0	180	99	0
5	0	350	194	0
6	0	149	104	0
Average	0	209	132	0

As shown in Table 4.5, a temperature of 10°C was evidently too low for the production of eggs. However, three of the six females kept at this temperature were still alive after one month. These females were then transferred to room temperature and after 12 days they started with normal egg laying. Although females are thus not killed at 10°C, egg production is inhibited. A temperature of 40°C was too high for egg laying and all the females were dead after one month. Three of the females kept at 30°C died without egg laying, but the other three produced eggs normally. As shown in Table 4.5, eggs were produced normally by all the females kept at a constant temperature of 25°C. An analysis of variance to indicate any statistical difference between the number of eggs produced at 25°C and that at 30°C, was negative at the 5% level ($F=1,0740$).

4.3.7 INFLUENCE OF RELATIVE HUMIDITY

Two desiccators with constant relative humidities of 32,5 and

75,5 per cent respectively and each containing six females, were kept at a constant temperature of 25°C. After a period of one month the total number of eggs per female was determined. The results are shown in Table 4.6.

Table 4.6 : Total number of eggs oviposited per female of M. capensis at different relative humidities and a constant temperature (25°C).

Replicate	Percentage relative humidity 32,5	75,5
1	217	134
2	331	360
3	205	78
4	133	180
5	337	350
6	207	149
Average	238	209

These results and in comparison with Table 4.4 show clearly that oviposition took place normally at the different relative humidities tested. Even at a relative humidity as low as 32,5 per cent, the average number of eggs per female was still higher than at 75,5 per cent. An analysis of variance showed no difference at the 5% level between the two treatments (F=0,2621).

4.3.8 INFLUENCE OF SOIL MOISTURE

Females were kept at a constant temperature of 25°C in glass tubes filled with soil of which the moisture content was kept constant at 2, 6, 10, 14, 22 and 30 per cent respectively. The field-capacity and saturation percentage of the soil were

20 and 32 per cent respectively. The total number of eggs per female at each treatment is shown in Table 4.7.

Table 4.7 : Total number of eggs oviposited per female of M. capensis at different percentages soil moisture and a constant temperature of 25°C.

Replicate	Percentage soil moisture 2	6	10	14	22	30
1	86	140	-	-	-	61
2	4	291	112	146	322	195
3	10	421	155	263	317	91
4	132	197	178	192	127	127
Average	58	262	148	200	255	119

The results show clearly that oviposition occurred over a wide range of soil moisture conditions : eggs were laid in dry soil with a moisture content as low as 2 per cent as well as in wet soil with a moisture content of 30 per cent. Oviposition was not inhibited when the percentage soil moisture exceeded that at field-capacity and eggs were laid even when it was very near the saturation percentage.

An analysis of variance of these results showed that significant differences occurred between treatments at the 5% level ($F=3,6033$). Tuckey's test of D-values indicated that the number of eggs produced at 2 per cent soil moisture differed from that at 6 and 22 per cent. No other differences could be detected. Oviposition is thus not markedly influenced by soil moisture but the number of eggs produced at a soil moisture of 2 per cent could be lower than that at percentages varying between 6 and 30 per cent. According to González et al.

(1969) fewer eggs are also oviposited by M. vitis when the soil moisture is less than 10 per cent.

4.4 INCUBATION OF EGGS

4.4.1 INFLUENCE OF RELATIVE HUMIDITY

Three desiccators with constant relative humidities of 32,5; 75,5 and 100 per cent respectively were kept at 25°C. Two hundred and fifty one day old eggs were placed in each desiccator and the larvae that emerged were counted and removed after 20, 34, 41 and 48 days respectively as mentioned in paragraph 4.1.3. The results are shown in the following table.

Table 4.8A : Total number of eggs of M. capensis hatched at certain periods after oviposition at different relative humidities and a constant temperature of 25°C (250 eggs per treatment).

Percentage humidity	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days
32,5	0	0	0	0
75,5	0	0	0	0
100	0	45	1	0

As shown in Table 4.8A, no eggs hatched at relative humidities of 32,5 and 75,5 per cent. At a relative humidity of 100 per cent a number of eggs hatched and the incubation period was longer than 20 but shorter than 41 days.

At each observation the number of live eggs was also counted. The figures shown in Table 4.8B are that of live plus ecloded eggs.

Table 4.8B : Total number of live and ecloded eggs of M. capensis at certain periods after oviposition at different relative humidities and a constant temperature of 25°C (250 eggs per treatment).

Percentage humidity	Number of live and ecloded eggs After 20 days	After 34 days	After 41 days	After 48 days
32,5	68	4	0	0
75,5	92	0	0	0
100	224	143	6	0

The results show that only a small number of the original number of eggs was alive after 20 days at relative humidities of 32,5 and 75,5 per cent. After 34 days all the eggs at 75,5 per cent were dead and at 32,5 per cent only 1,6 per cent of the original number were still alive. As shown in Table 4.8A, these relative humidities were too low for hatching of the eggs. It now appears that they were too low for the normal development of the eggs to larvae. At 100 per cent humidity, 90 per cent of the eggs were alive after 20 days while 57 per cent were alive after 34 days. This indicates that the larvae had developed normally in the eggs at a relative humidity of 100 per cent.

4.4.2 INFLUENCE OF TEMPERATURE AT A CONSTANT RELATIVE HUMIDITY

Four desiccators, each with a constant relative humidity of 100 per cent and containing 250 one day old eggs, were kept individually at 40, 30, 25 and 10°C. Larvae were counted and removed after 20, 34, 41 and 48 days respectively as mentioned

in paragraph 4.1.3. These results are shown in the following table.

Table 4.9A : Total number of eggs of M. capensis hatched at certain periods after oviposition at different temperatures and a constant relative humidity (250 eggs per treatment).

Tempertature °C	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days
40	0	0	0	0
30	0	26	0	0
25	0	45	1	0
10	0	0	0	0

As indicated in Table 4.9A eggs did not hatch at temperatures of 40 and 10°C which were evidently too high and too low respectively. Some eggs, however, developed and hatched at 30 and 25°C. Although the total number of larvae after 34 days at 25°C was higher than that at 30°C, an analysis of variance showed no statistical difference between the two treatments (F=0,3170). The incubation period was more than 20 but shorter than 41 days.

The number of live eggs was counted after 20 and 34 days respectively. Afterwards it was counted at intervals of 7 days. The figures given in Table 4.9B are that of live and ecloded eggs.

Table 4.9B : Total number of live and ecloded eggs of M. capensis at certain periods after ovipostion at different temperatures and a constant relative humidity (250 eggs per treatment).

Temperatures °C	Number of live and ecloded eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
40	0	0	0	0	0
30	159	75	15	0	0
25	224	143	6	0	0
10	237	165	79	64	58

The results show that all the eggs at 40°C were dead after 20 days, indicating that this temperature was too high for the normal development of eggs to larvae. At 10°C, 66 per cent of the original number of eggs were alive after 34 days and 23 per cent even after 55 days. All the eggs were eventually dead after 81 days. A temperature of 10°C was therefore not fatal to the eggs, but it was evidently too low for their normal development. After 34 days, 30 per cent of the original number of eggs were still alive at 30°C and 57 per cent were alive at 25°C. This indicates that the normal development of the eggs was not inhibited at these temperatures. An analysis of variance to indicate any differences between the number of live eggs at 25 and 30°C was negative at the 5% level (F=4,0776). An analysis of variance of the results obtained after 41 days, was also negative at the 5% level (F=1,0658).

4.4.3 INFLUENCE OF SOIL MOISTURE

The influence of soil moisture on the incubation of eggs was tested at 2, 10, 19, 27 and 35 per cent and at 25°C. The field-capacity and saturation percentage of the soil were 20

and 32 per cent respectively. Observations were made on 60 one day old eggs per treatment. The number of larvae was determined after 20, 34, 41, 48 and 55 days respectively as mentioned in paragraph 4.1.3. The results are shown in the following table.

Table 4.10A : Total number of eggs of M. capensis hatched at certain periods after oviposition at different percentages soil moisture and a constant temperature of 25°C (60 eggs per treatment).

Percentage soil moisture	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
2	0	0	1	0	0
10	0	0	0	0	0
19	0	0	3	0	0
27	0	0	8	0	0
35	0	0	26	2	0

The results show that a very small percentage of eggs may hatch with the soil moisture content as low as 2 per cent and that the percentage that hatched increases at higher soil moisture contents. This is in agreement with the finding that a high relative humidity is favourable for egg eclosion. Larvae also occurred in wet soil of which the percentage soil moisture exceeds that at field-capacity and even that at saturation percentage. The incubation period was more than 34 but shorter than 48 days.

An analysis of variance of the results showed that significant differences occurred between treatments at the 5% level ($F=3,7514$). Tuckey's test of D-values indicated that the num-

ber of larvae that had emerged at 35 per cent soil moisture differed from that at 2, 10 and 19 per cent. No other statistical differences could be detected. Dead eggs were counted at each observation and the results are given in Table 4.10B.

Table 4.10B : Total number of dead eggs of M. capensis out of 60 per treatment at certain periods after oviposition at different percentages of soil moisture and a constant temperature of 25°C.

Percentage soil moisture	Number of dead eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
2	38	53	59	-	-
10	25	34	55	60	-
19	44	49	54	57	-
27	10	41	46	50	52
35	10	12	24	27	32

Table 4.10B shows that the eggs that did not hatch at a soil moisture content of 2 per cent, were all dead after 41 days. The eggs at 10 and 19 per cent were dead after 48 days and those at 27 and 35 per cent only after 55 days. The survival of eggs is evidently prolonged when the percentage soil moisture exceeds that at field-capacity. At each observation the mortality of eggs was lower or as low at 35 per cent than at the other percentages soil moisture tested. The results obtained after 41 days were statistically analysed and an analysis of variance showed that highly significant differences ($P<0,01$) occurred between the treatments ($F=8,8159$). Tuckey's test of D-values showed that the mortality of eggs at 35 per cent was significantly lower than that at the other percen-

tages tested. The results indicate that the survival and mortality of eggs in wet soils are respectively longer and lower than that of eggs in dry soil.

4.4.4 INFLUENCE OF TEMPERATURE AT A CONSTANT SOIL MOISTURE

The influence of temperature on the incubation of eggs was tested at 10, 25, 30 and 40°C and at a constant soil moisture of 27 per cent. The field capacity and saturation percentage of the soil were 20 and 32 per cent respectively. Observations were made with 75 one day old eggs per treatment and the number of larvae was determined after 20 and 34 days respectively and thereafter at intervals of 7 days. The results are shown in the following table.

Table 4.11A : Total number of eggs of M. capensis hatched at certain periods after oviposition at different temperatures and a constant soil moisture (75 eggs per treatment).

Temperature °C	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
10	0	0	0	0	0	0
25	0	4	7	0	0	0
30	0	0	0	0	0	0
40	0	0	0	0	0	0

Larvae occurred only at a temperature of 25°C and the incubation period was more than 20 but shorter than 48 days (Table 4.11A). A temperature of 10°C was too low for the hatching of eggs while 30 and 40°C were too high.

During each observation dead eggs were also counted and the results are shown in Table 4.11B.

Table 4.11B : Total number of dead eggs of M. capensis out of 75 per treatment at certain periods after oviposition at different temperatures and a constant soil moisture.

Temperature °C	Number of dead eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
10	7	18	28	42	50	75
25	27	49	57	64	-	-
30	42	75	-	-	-	-
40	75	-	-	-	-	-

The results show that all the eggs at 40 and 30°C were dead after 20 and 34 days respectively, indicating that these temperatures were too high for the normal development of eggs to larvae. At 10°C, 63 per cent of the original number of eggs were still alive after 41 days and 100 per cent mortality was reached only after 62 days. Eggs were thus not killed at a temperature of 10°C but as already mentioned in paragraph 4.4.2 it was evidently too low for the normal development of eggs. Eggs only hatched at a temperature of 25°C indicating that at this temperature the eggs can develop normally.

In the results of the incubation of eggs (par. 4.4) the percentage of eggs that hatched was often very low, even at apparently favourable conditions. This was probably partly due to the fact that the eggs were removed manually and were often disturbed during observations.

During each observation dead eggs were also counted and the results are shown in Table 4.11B.

Table 4.11B : Total number of dead eggs of M. capensis out of 75 per treatment at certain periods after oviposition at different temperatures and a constant soil moisture.

Temperature °C	Number of dead eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
10	7	18	28	42	50	75
25	27	49	57	64	-	-
30	42	75	-	-	-	-
40	75	-	-	-	-	-

The results show that all the eggs at 40 and 30°C were dead after 20 and 34 days respectively, indicating that these temperatures were too high for the normal development of eggs to larvae. At 10°C, 63 per cent of the original number of eggs were still alive after 41 days and 100 per cent mortality was reached only after 62 days. Eggs were thus not killed at a temperature of 10°C but as already mentioned in paragraph 4.4.2 it was evidently too low for the normal development of eggs. Eggs only hatched at a temperature of 25°C indicating that at this temperature the eggs can develop normally.

In the results of the incubation of eggs (par. 4.4) the percentage of eggs that hatched was often very low, even at apparently favourable conditions. This was probably partly due to the fact that the eggs were removed manually and were often disturbed during observations.

As mentioned in paragraph 4.1.3, intervals between observations were kept relatively long in order to reduce disturbance of the eggs and conditions in the desiccators and the exact incubation period could therefore not be determined. This period was, however, more accurately determined in a succeeding experiment. Four hundred one day old eggs were placed in embryonic watch glasses and kept at 25°C in desiccators with a constant relative humidity of 100 per cent. After a period of 20 days the eggs were observed every second or third day and emerging larvae were counted and removed. Of the total number of eggs 56,8 per cent hatched, the rest being dead after 49 days. The incubation period was between 34 and 43 days. Of the total number of eggs hatched, 90,8 per cent hatched between the 36th and 38th day after oviposition. This incubation period is exceptionally long compared to that of M. vitis which is between 10 and 15 days (González, et al. 1969) and to that of Neomargarodes setosus (a grass infesting species from Russia) which is between 12 and 16 days (Khadzhibeyli, 1966).

4.5 DEVELOPMENT OF FIRST INSTAR LARVAE TO ADULT FEMALES

Within seven days after the larvae had been placed on the roots in the petri dishes, wax threads started to develop on the thorax - two on each side. Five days later wax threads also started to develop on the sides of the abdomen. Apparently these threads develop through the spiracles. As the wax threads become longer, the body becomes thicker and the segmentation less visible (Fig. 4.6A).

After four weeks a thin layer of wax was formed on the posterior end of the abdomen and after two months the whole body with legs and antennae was covered. The first instar larvae

were thus covered with a cyst wall after two months (Fig. 4.6B). These encysted larvae were removed from the roots after three months of development and mounted on microscope slides. At this stage the cyst wall was smooth and bright yellow in colour. Of the five cysts investigated, all were in the nymph (cyst) stage, indicating that first instar larvae moult and develop into nymphs between two and three months after hatching from the eggs.

The duration of the cyst stage was further determined in plastic bags. Of the 24 vines originally infested with adult females, none were infested with cysts even after one year. With the second experiment the same negative results were obtained. The duration of the cyst stage could thus not be determined. According to González *et al*. (1969) first instar larvae of *M. vitis* develop into cysts of the first stage within 2 to 3 weeks. After 8 to 9 months this stage moults into the second stage cyst and after another 12 months it moults again into a third stage cyst. As the duration of the third stage is unknown, the whole duration of development from cyst to adult female could not be determined for this species. The cysts of the third stage may even remain viable for up to twelve years (González *et al*. 1969).

Fig. 4.6A (above) : First instar larva of M. capensis with wax threads - fourteen days after hatching from the egg.

Fig. 4.6B (below) : Encysted first instar larva of M. capensis with wax threads - three months after hatching from the egg.

5. BIOLOGY OF MARGARODES CAPENSIS UNDER FIELD CONDITIONS

5.1 MATERIAL AND METHODS

To determine the time of occurrence of the different stages in the lifecycle of M. capensis as well as the vertical distribution of each stage in the soil, observations were made from October 1974 until September 1975 in a heavily infested vineyard in the Paardeberg area near Malmesbury. Observations were made at intervals of four weeks, except during the period of occurrence of the adult females and first instar larvae, when the observations were made fortnightly. As a result of heavy rainfall, observations could not be made on 1975-07-01 and again on 1975-08-26. Sixteen observations were thus made during the year.

Three vines were chosen at random, regardless of vigour, for each observation. They were selected from a small area (about 900m^2) in the vineyard to avoid the possible influence of soil type on the population. A ditch 45 cm wide, 1,5 m long and 1,2 m deep, was dug 30 cm away from each vine and at right angles with the rows (Fig. 5.1). Layers of soil, each 15 cm deep, were removed from the end of the ditch towards the vine to a depth of 1,2 m (Fig. 5.1). Of the total amount of soil from each layer, small quantities were taken at random to obtain a sample of three or four litres. In the laboratory one litre of soil was taken at random from this sample and washed with water through three sieves with apertures of 2,8; 2,0 and 1,0 mm respectively. The cysts obtained in each sieve were removed and those with an emergence orifice (empty cysts) were separated from the others and counted. The total number of the remaining cysts from each sieve was then determined.

As the majority of live cysts sank in water (par. 4.1.1), the percentage mortality could also be determined.

Fig. 5.1 : A ditch dug at right angles with the vine rows in Malmesbury for sampling populations of M. capensis on vine roots and in soil layers of 15 cm down to a depth of 1,2 m.

As females, eggs and first instar larvae of M. capensis float in water, a second litre of soil from each layer was placed in a Seinhorst elutriator (Seinhorst, 1964) and washed, with a waterflow of 10 litre per minute through a sieve with apertures of 88 micron. The females so obtained were removed from the sieve and counted. The rest of the content of the sieve was washed with water through a 15 x 15 cm cheesecloth filter and the number of eggs and larvae so obtained were determined under a stereo microscope. Each filter was marked

with cross-wise lines by means of a sewing machine for easier and more accurate examination under the microscope.

During the excavations in the field, a small quantity of soil from each layer was placed in an airtight container. The percentage moisture content of the soil was determined on a dry-mass basis as described by Gardner (1965).

The daily maximum, minimum and mean air temperatures as well as the daily rainfall for the whole period of observation were supplied from a nearby meteorological station by the Fruit and Fruit Technology Research Institute.

To assure that observations were made only once at each vine, all data vines were marked after an excavation. Results could not always be obtained at all of the data vines, because the soil was too hard (during summer) or too wet (during winter) for excavations to be made to the required depth of 1,2 m.

5.2 PHENOLOGY

To determine the time of occurrence of adult females, eggs, larvae and cysts the total number found in the seven layers of soil down to a depth of 105 cm was calculated for each sampled vine on each date of observation.

5.2.1 TIME OF OCCURRENCE OF CYSTS

The total number of cysts of all sizes for each vine and on each date of observation is shown in Table 5.1. From these results it is clear that cysts occur throughout the whole year. It is also clear that great variations occurred in the population density between different vines at the same date of observation as well as between the different dates of observation. It was impossible to determine peaks of

occurrence of cysts, if any should appear.

The total number of cysts greater than 2,8 mm per vine and at each date of observation is shown in Table 5.2. The same data for cysts in the size ranges 2,0 - 2,8 and 1,0 - 2,0 mm are shown in Tables 5.3 and 5.4 respectively. From these results it is clear that small as well as big cysts occur throughout the year. Considerable variation occurred in the population density of cysts of all three size ranges between different vines on the same date of observation as well as between the various dates of observation. No peaks of occurrence were evident.

The variation in the population density of cysts was possibly due to the uneven distribution of the infestation throughout the vineyard as well as the abundance and quality of the roots of each vine, which in turn may be a function of the previous infestation levels. The presence of small cysts (1,0 - 2,0 mm) throughout the whole year indicates that a cyst can not develop to its maximum size within a period of one year. This is in agreement with the life cycle of M. vitis where the cyst stage lasts even longer than two years (González et al. 1969). The occurrence of cysts throughout the year indicates clearly that the whole population does not develop into adult females during a period of one year. During the emergence period of females the ratio between the number of cysts greater than 2,8 mm and the number of females found was 16 : 1. In the laboratory it was found that only 5 to 10 per cent of a cyst population develop annually into females (par. 4.2.2).

The total average of cysts greater than 2,8 mm per vine for the whole period of observation was 93. Of cysts in the size

Table 5.1 : Total numbers of cysts (all sizes) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	151	101	164	139
19-11-74	101	42	-	72
17-12-74	253	-	-	253
31-12-74	149	143	62	118
14- 1-75	158	146	44	116
28- 1-75	68	69	350	162
11- 2-75	171	-	-	171
25- 2-75	53	295	159	169
11- 3-75	-	47	33	40
25- 3-75	79	182	34	98
8- 4-75	83	44	-	64
22- 4-75	154	68	-	111
20- 5-75	189	108	324	207
3- 6-75	238	-	-	238
29- 7-75	31	56	-	44
23- 9-75	184	158	-	171

Table 5.2 : Total number of cysts (greater than 2,8 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	79	65	94	79
19-11-74	65	32	-	49
17-12-74	134	-	-	134
31-12-74	101	79	37	72
14- 1-75	92	99	32	74
28- 1-75	48	50	290	129
11- 2-75	152	-	-	152
25- 2-75	27	248	125	133
11- 3-75	-	32	23	28
25- 3-75	44	150	23	72
8- 4-75	61	33	-	47
22- 4-75	130	44	-	87
20- 5-75	120	62	177	120
3- 6-75	176	-	-	176
29- 7-75	28	43	-	36
23- 9-75	88	111	-	100

Table 5.3 : Total number of cysts (2,0 - 2,8 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	44	28	42	38
19-11-74	22	9	-	16
17-12-74	57	-	-	57
31-12-74	27	39	10	25
14- 1-75	37	29	7	24
28- 1-75	12	13	38	21
11- 2-75	13	-	-	13
25- 2-75	16	43	19	26
11- 3-75	-	9	3	6
25- 3-75	24	28	3	18
8- 4-75	15	5	-	10
22- 4-75	21	14	-	18
20- 5-75	46	22	69	46
3- 6-75	48	-	-	48
29- 7-75	3	7	-	5
23- 9-75	59	32	-	46

Table 5.4 : Total number of cysts (1,0 - 2,0 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	28	8	28	21
19-11-74	14	1	-	8
17-12-74	62	-	-	62
31-12-74	21	25	15	20
14- 1-75	29	18	5	17
28- 1-75	8	6	22	12
11- 2-75	6	-	-	6
25- 2-75	10	4	15	10
11- 3-75	-	6	7	7
25- 3-75	11	4	8	8
8- 4-75	7	6	-	7
22- 4-75	3	10	-	7
20- 5-75	23	24	78	42
3- 6-75	14	-	-	14
29- 7-75	0	6	-	3
23- 9-75	37	15	-	26

ranges 2,8 - 2,0 and 2,0 - 1,0 mm the total average per vine was 26 and 17 respectively. The high population of big cysts is probably due to the fact that only a small percentage develop into females annually.

5.2.2 TIME OF OCCURRENCE OF EMPTY CYSTS

The total number of empty cysts of all sizes for each vine and at each date of observation is shown in Table 5.5. From these results it is clear that empty cysts occur throughout the whole year. The presence of empty cysts during months other than that in which females emerge (par. 5.2.3), shows that the substance of the cyst wall is probably of such a material that it could not decay within a period of one year. During the emergence period of females, the ratio between the number of empty cysts (all sizes) and the number of females found, was 6 : 1. This indicates that empty cysts could remain in the soil without decaying even for periods longer than one year. From Table 5.5 it is also clear that great variation occurred in the number of empty cysts found at different vines at the same date of observation as well as between different dates of observations. Peaks in the occurrence of empty cysts during the year could thus not be determined. This variation is probably due to the variable number of live cysts and to the accumulation of empty cysts over successive years.

The total number of empty cysts greater than 2,8 mm for each vine and at each date of observation is shown in Table 5.6. The same data for empty cysts in the size ranges 2,0 - 2,8 and 1,0 - 2,0 mm are shown in Table 5.7 and 5.8 respectively. These results indicate clearly that big as well as small empty cysts are found during the whole year. As great variations

Table 5.5 : Total number of empty cysts (all sizes) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-75	15	29	6	17
19-11-74	6	13	-	10
17-12-74	31	-	-	31
31-12-74	37	65	8	37
14- 1-75	32	26	3	20
28- 1-75	2	15	145	54
11- 2-75	91	-	-	91
25- 2-75	18	83	29	43
11- 3-75	-	18	14	16
25- 3-75	21	26	14	20
8- 4-75	59	27	-	43
22- 4-75	42	30	-	36
20- 5-75	25	12	49	29
3- 6-75	50	-	-	50
29- 7-75	1	6	-	4
23- 9-75	37	44	-	41

Table 5.6 : Total number of empty cysts (greater than 2,8 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	8	19	5	11
19-11-74	6	11	-	9
17-12-74	21	-	-	21
31-12-74	28	28	5	20
14- 1-75	21	25	3	16
28- 1-75	2	9	106	39
11- 2-75	88	-	-	88
25- 2-75	14	75	25	38
11- 3-75	-	15	11	13
25- 3-75	12	24	9	15
8- 4-75	48	18	-	33
22- 4-75	32	20	-	26
20- 5-75	17	6	36	20
3- 6-75	28	-	-	28
29- 7-75	1	4	-	3
23- 9-75	11	32	-	21

Table 5.7 : Total number of empty cysts (2,0 - 2,8 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	7	3	1	4
19-11-74	0	2	-	1
17-12-74	6	-	-	6
31-12-74	8	26	1	12
14- 1-75	8	1	0	3
28- 1-75	0	3	27	10
11- 2-75	2	-	-	2
25- 2-75	3	7	2	4
11- 3-75	-	2	3	3
25- 3-75	0	0	2	1
8- 4-75	7	5	-	6
22- 4-75	3	6	-	5
20- 5-75	7	1	5	4
3- 6-75	18	-	-	18
29- 7-75	0	1	-	1
23- 9-75	11	5	-	8

Table 5.8 : Total number of empty cysts (1,0 - 2,0 mm in diameter) of M. capensis sampled per vine in Malmesbury from October 1974 to September 1975.

Date	Vine No. I	Vine No. II	Vine No. III	Average
22-10-74	0	7	0	2
19-11-74	0	0	-	0
17-12-74	4	-	-	4
31-12-74	1	11	-	5
14- 1-75	3	0	0	1
28- 1-75	0	3	12	5
11- 2-75	1	-	-	1
25- 2-75	1	1	2	1
11- 3-75	-	1	0	1
25- 3-75	9	2	3	5
8- 4-75	4	4	-	4
22- 4-75	7	4	-	6
20- 5-75	1	5	8	5
3- 6-75	4	-	-	4
29- 7-75	0	1	-	1
23- 9-75	15	7	-	11

also occurred in the number of empty cysts of all three size ranges at different vines at the same date of observation as well as between the various dates of observations, peaks of their occurrence during the year could thus not be determined.

The total average of empty cysts greater than 2,8 mm per vine for the whole period of observation was 25. Of empty cysts in the size ranges 2,8 - 2,0 and 2,0 - 1,0 mm the total average per vine was 6 and 4 respectively. The occurrence of small empty cysts indicates that cysts could develop into adult females without reaching the maximum size. This could possibly be caused by inadequate nourishment, resulting from feeding on a decaying or dying root.

5.2.3 TIME OF OCCURRENCE OF ADULT FEMALES

Adult females were found for the first time in the middle of December. During the second half of December and the whole of January their numbers were constant and at a low level. From the beginning of February the numbers increased sharply, reaching a peak from the end of February to the middle of March (Fig. 5.2). During the second half of March towards the middle of April the numbers decreased sharply. At the middle of May their numbers increased again slightly but from the beginning of June females were absent.

The maximum, mean and minimum daily air temperatures per month for the period of observation are given in Figure 5.3. From Figures 5.2 and 5.3 it is evident that the females emerge from the cysts at a time when the mean monthly temperatures ranged from 14,8°C (May) to 24,2°C (Febr.). Mean monthly temperatures during September, October and November are within this range

FIG. 5.2 : AVERAGE NUMBER OF ADULT FEMALES OF M. CAPENSIS PER VINE SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 48 VINES.

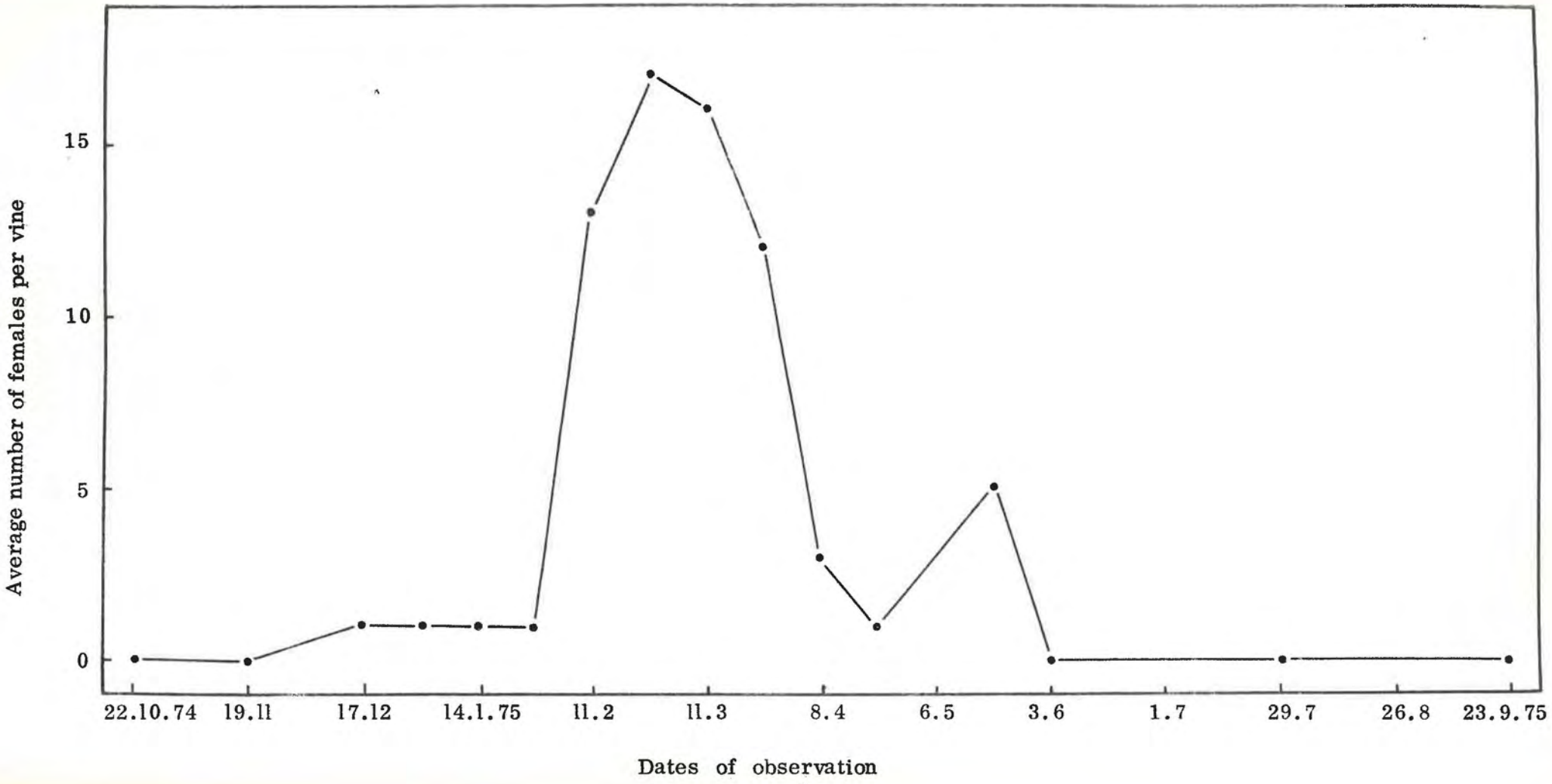
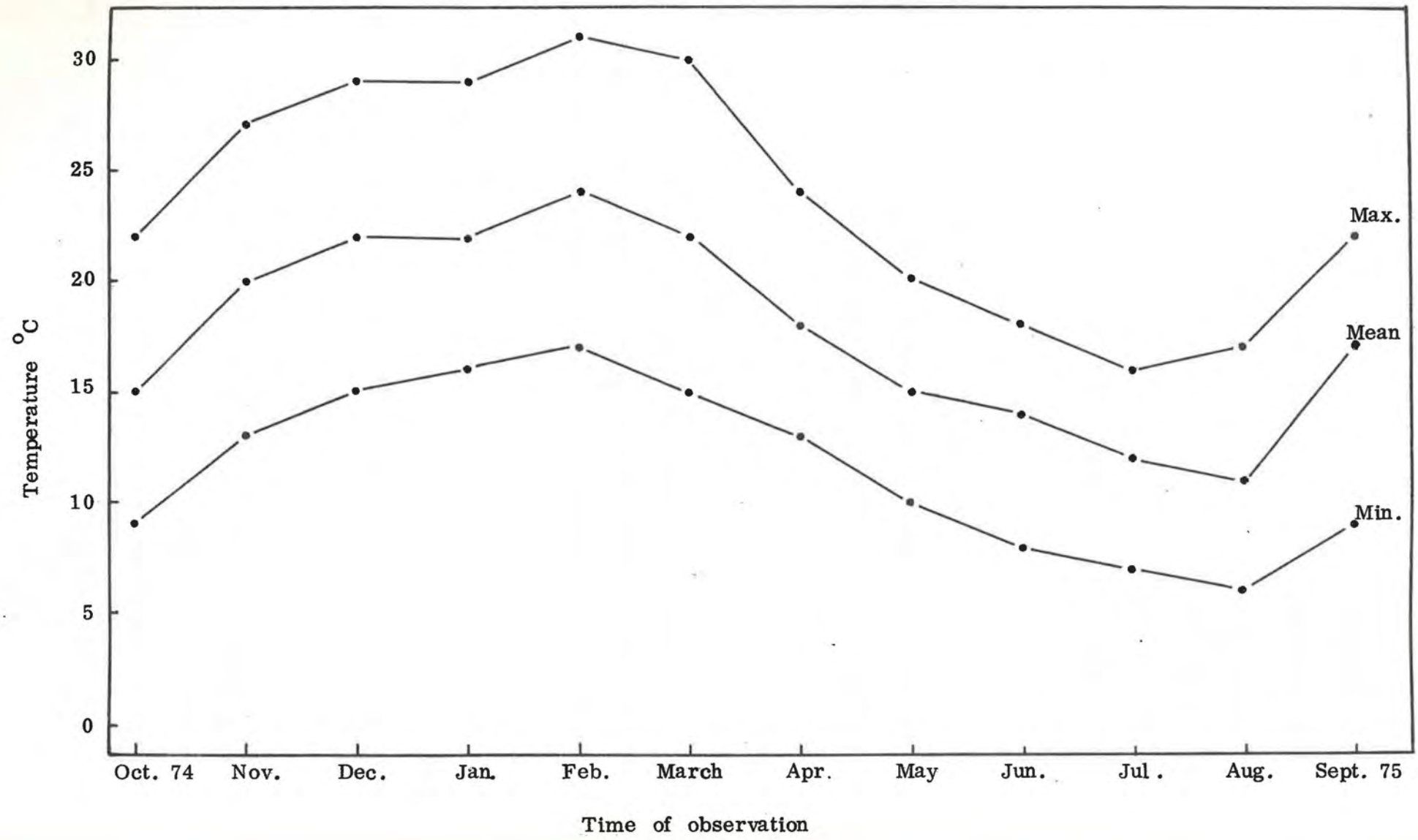


FIG. 5.3 : MAXIMUM, MEAN AND MINIMUM DAILY AIR TEMPERATURE PER MONTH FROM OCTOBER 1974 TO SEPTEMBER 1975 IN THE MALMESBURY AREA.

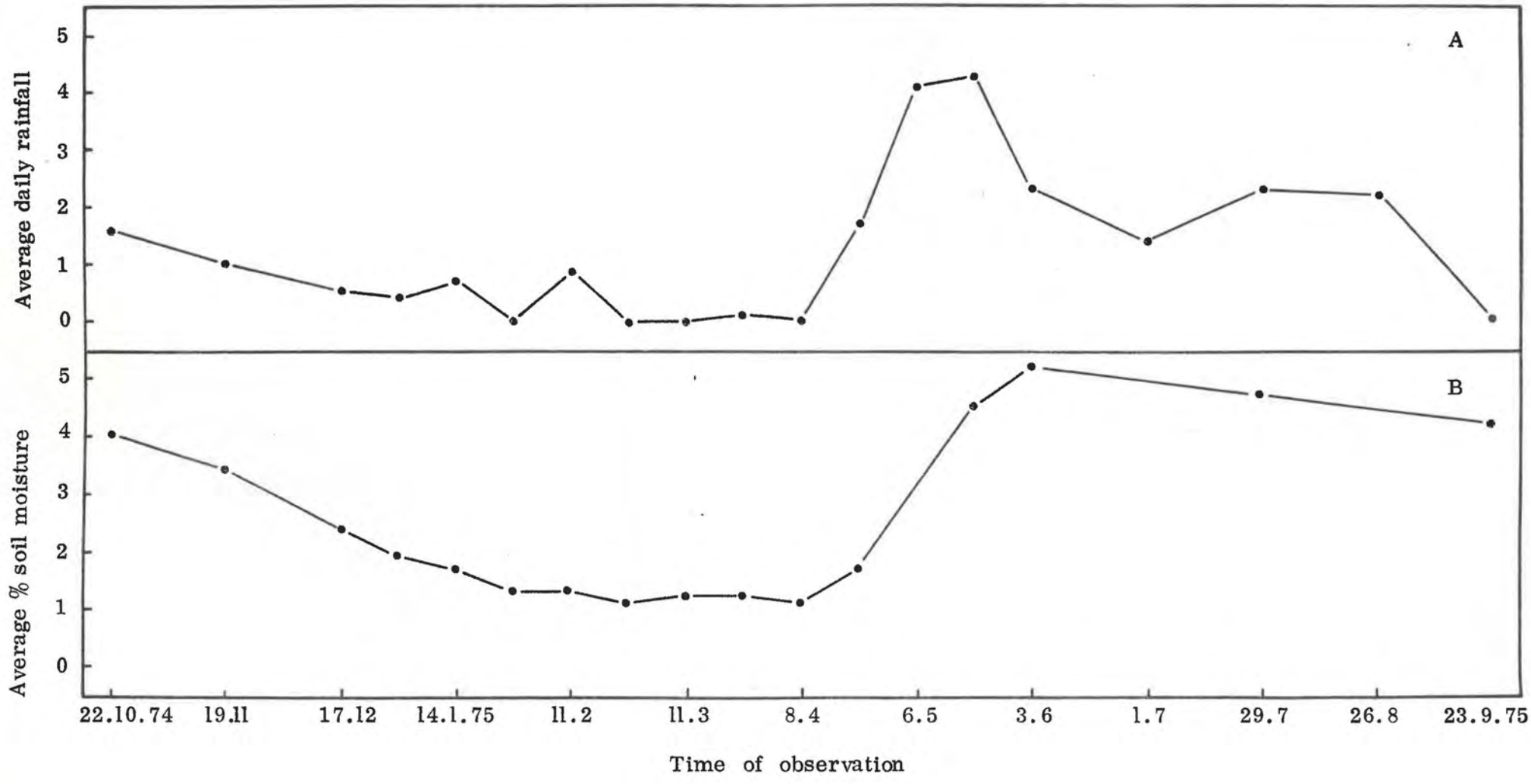


but no females were found. The females occurred when maximum temperatures ranged from 19,8°C (May) to 31,4°C (Febr.), but were absent during September, October and November when the maximum temperatures were also within this range. The minimum temperatures when the females occurred ranged from 9,7°C (May) to 17,0°C (Febr.). The minimum temperature during November, however, coincide with this range and females were absent. It would seem, therefore, that these temperatures were not direct factors influencing the occurrence of females.

As shown in Figure 5.2 most of the females (81,7%) were found during February and March. The mean temperatures for February and March were 24,2 and 22,4°C respectively. The mean temperature for January (22,3°C) was similar to that of March but the number of females found, was very low. The minimum temperatures for February and March were 17,0 and 15,2°C respectively. The minimum temperature for January (15,7°C) was even higher than that for March but the number of females found, however, was very low. These results suggest that mean and minimum temperatures are not direct factors influencing the peak in the occurrence of females. The maximum temperatures for February and March were 31,4 and 29,5°C respectively. The maximum temperatures for December and January, when the female population was very low, were 28,7 and 28,8°C respectively. A peak in the number of adult females thus occured when the maximum monthly air temperature increased above 29°C.

The average daily rainfall in mm and the average percentage soil moisture content of all the layers together for each date of observation are shown in Figure 5.4A and 5.4B respectively. These figures show clearly that the soil moisture content cor-

FIG. 5.4 : (A) AVERAGE DAILY RAINFALL IN MM AND (B) AVERAGE PERCENTAGE SOIL MOISTURE CONTENT ON VARIOUS DATES BETWEEN OCTOBER 1974 TO SEPTEMBER 1975 IN THE MALMESBURY AREA.

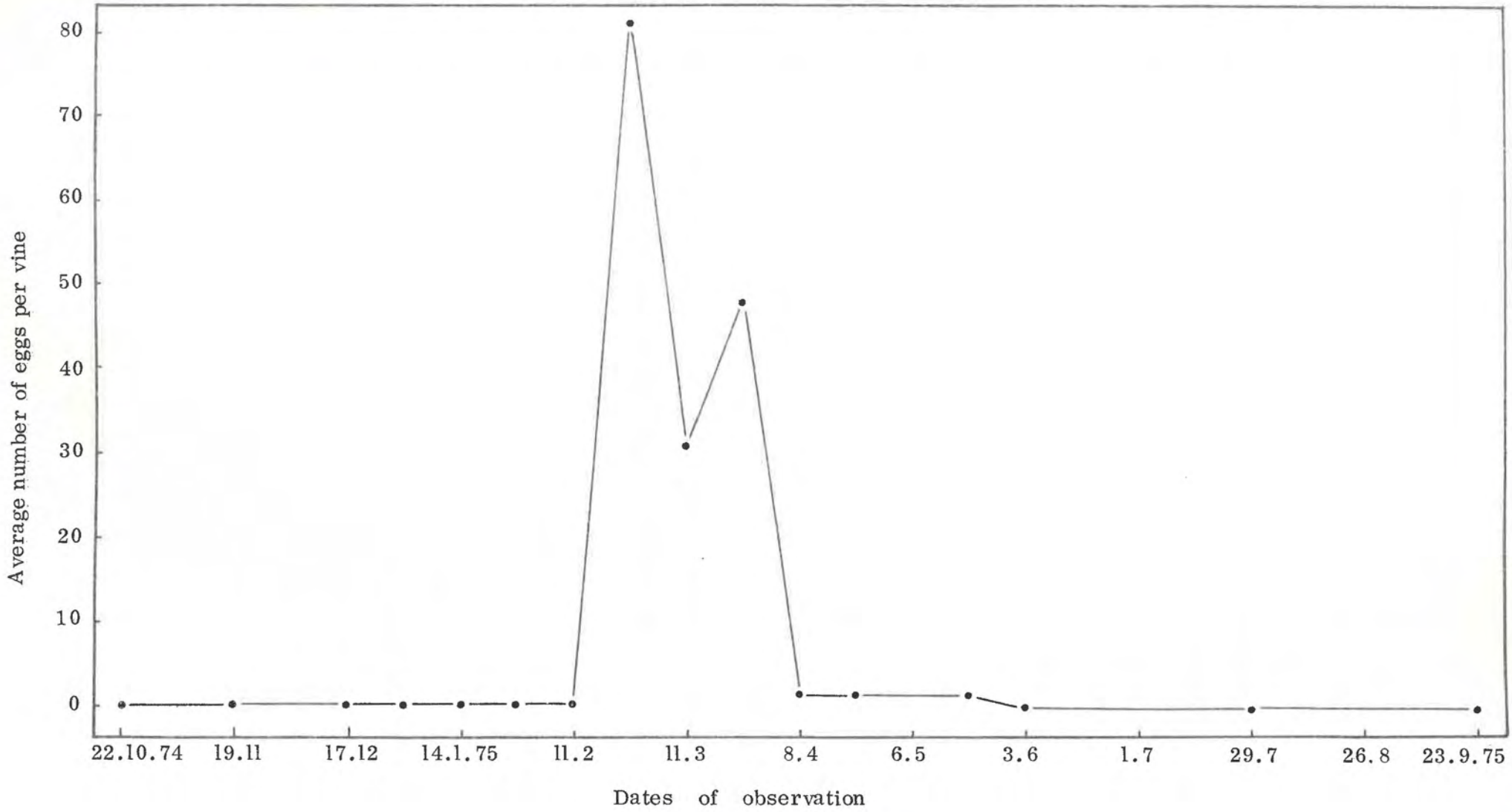


responds very closely with rainfall. An increase in rainfall results in an increase in soil moisture content through all eight layers within 14 days. A comparison between Figures 5.2 and 5.4 shows that adult females occur when the soil moisture is very low. The peak in the occurrence of females actually occurs when the percentage soil moisture is at its lowest and varies between 1,13 and 1,33. The percentage soil moisture content at the end of January and at the beginning of April when the female numbers were very low, also fall within this range - indicating that low soil moisture content does not directly influence the peak in the occurrence of adult females.

5.2.4 TIME OF OCCURRENCE OF EGGS

Eggs were found for the first time at the end of February when their numbers were very high (Fig. 5.5). In March their numbers declined somewhat and during April their numbers were very low. From the beginning of June eggs were absent. As shown in Figure 5.2 and 5.5, a peak in the occurrence of eggs occurred at the same time as the peak in the number of females. The first eggs were, however, found almost two and a half months after the first appearance of females. The first females of a season could thus be infertile or delay egg production but it is more likely that the method used to determine the occurrence of eggs was not accurate enough to detect them when the number of females was low. The highest number of eggs is thus produced when the population of females is at its highest, the maximum temperature is at its highest and the soil moisture content is at its lowest.

FIG. 5.5 : AVERAGE NUMBER OF EGGS OF M. CAPENSIS PER VINE SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 48 VINES.



5.2.5 TIME OF OCCURRENCE OF FIRST INSTAR LARVAE

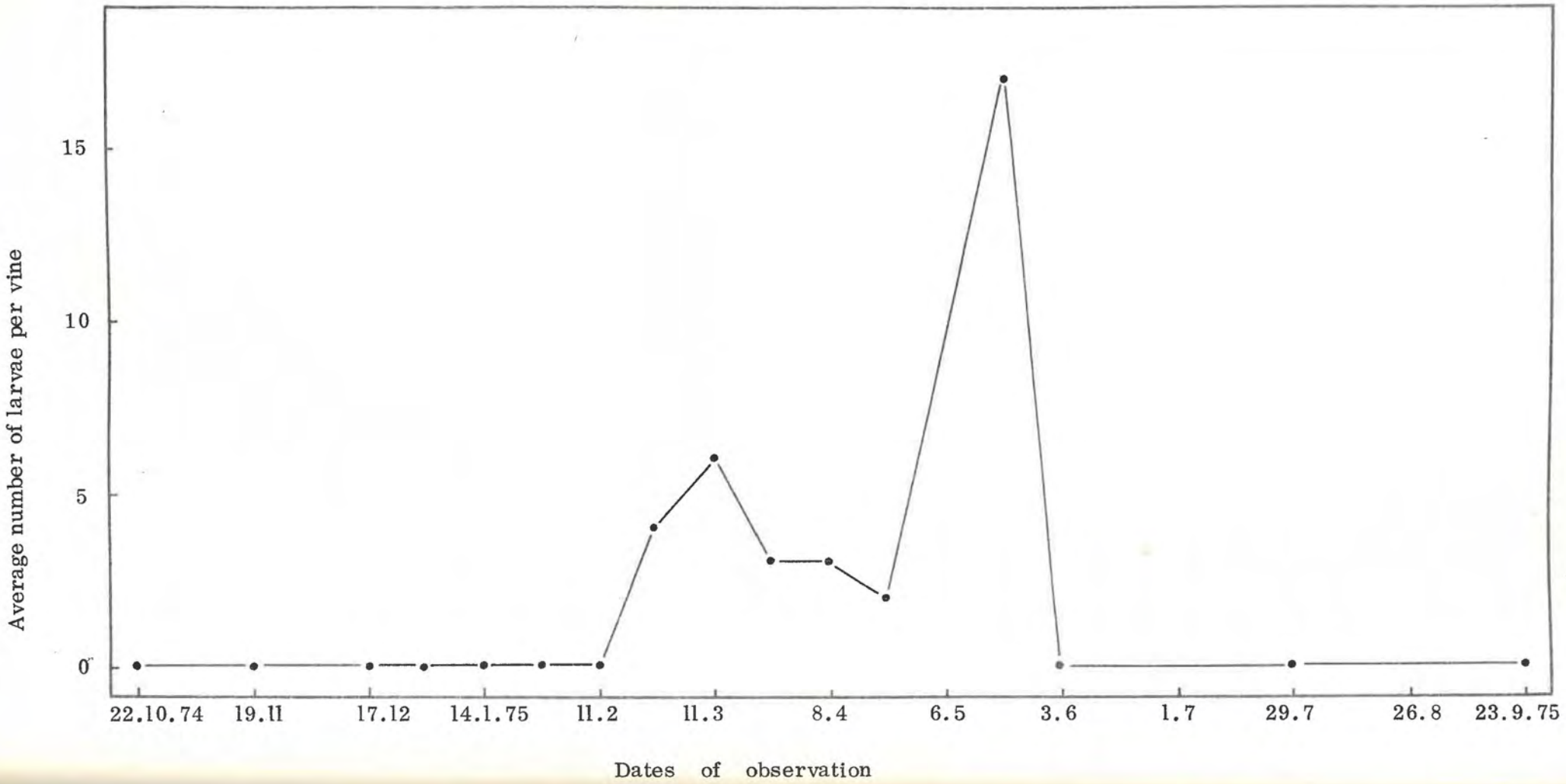
First instar larvae were found for the first time at the end of February. During March and April their numbers remained at a low level but then increased rapidly to form a peak in May. From the beginning of June larvae were again absent (Fig. 5.6). A comparison between Figures 5.2 and 5.6 shows that larvae were first found, as in the case of eggs, almost two and a half months after the first appearance of females. The peak in the occurrence of larvae was also approximately two and a half months after the number of females had reached a peak.

Figures 5.5 and 5.6 show that the peak in the presence of larvae occurred approximately two and a half months after the number of eggs had reached a peak. Larvae were first found on the same date as the first eggs - indicating, as mentioned in paragraph 5.2.4, that not all the eggs were detected when the number of females was low.

A comparison between Figure 5.6 and Figure 5.4A and 5.4B shows that the number of larvae was very low when the rainfall and soil moisture content were also very low (Febr. - April), and reached a peak after the first autumn rains, when the soil moisture content was almost at its highest (May).

These results indicate that although larvae could hatch under dry soil conditions, a high soil moisture content is more favourable. The peak in the occurrence of larvae was at the middle of May when the mean minimum temperature was 11,2°C. At the beginning of June when larvae were absent the soil moisture content was still very high but the mean minimum

FIG. 5.6 : AVERAGE NUMBER OF FIRST INSTAR LARVAE OF M. CAPENSIS PER VINE SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 48 VINES.



temperature dropped to 7,1°C. With observations in the laboratory it was found that eggs hatch at a constant temperature of 25°C and 30°C but not at 10°C (par. 4.4.2). Although a high soil moisture content is thus favourable for the occurrence of larvae, it seems that the minimum air temperature must be higher than 10°C.

5.2.6 OCCURRENCE OF MALES

During the whole year of investigation no males were observed and no male pupae were found in any of the soil samples. Evidently females reproduce parthenogenetically.

5.3 MORTALITY OF CYSTS

The average percentage mortality (par. 4.1.1) during the whole year of observation for cysts (cysts with emergence orifice excluded) in the size range greater than 2,8 mm; 2,0 - 2,8 mm and 1,0 - 2,0 mm was 13,1; 23,6 and 42,9 respectively. The low percentage mortality of big cysts (greater than 2,8 mm) possibly indicates that large cysts are more resistant to unfavourable conditions than smaller cysts because their walls are thicker and harder. According to González *et al*. (1969) most of the mature cysts of *M. vitis* lie loose in the soil without feeding. Possibly this stage is thus also less dependent on food quality. At a dying vine the mortality of small young cysts could thus be much higher than that of big cysts because of inadequate nourishment. The average percentage mortality of cysts of all three size ranges was 26,5. As mentioned in paragraph 5.2.2 empty cysts and thus also dead cysts, could remain in the soil without decaying for periods longer than one year. The accumulation of dead cysts

during successive years could thus have contributed to the high figure of dead cysts. The natural mortality of cysts during one year is thus possibly less than 26,5 per cent.

The average percentage mortality of cysts of all sizes per vine for each month of observation is shown in Figure 5.7. Evidently two peaks of mortality occurred during the year, the first during February and the second during July. When the cysts are grouped according to size, the mortality pattern for each group is very similar to that of the average for all the cysts together, i.e. mortality increases in the late summer and mid winter (Fig. 5.8).

As shown in Figure 5.4B the average percentage soil moisture content during January and April was almost the same as for February and March. That for June, August and September were also approximately the same as for July. The moisture content of the soil could thus not be the reason for the increased mortality of cysts during February, March and July.

A comparison between Figures 5.7 and 5.3 indicates that the mortality of cysts increases during spring and summer to a peak during February when the daily air temperature also reaches a peak. Afterwards it decreases during autumn as the temperature decreases. During July and possibly August when the temperature was at its lowest, the mortality of cysts reached another peak. High maximum temperatures during summer as well as low minimum temperatures during winter could thus possibly be direct factors influencing mortality of the cysts.

5.4 VERTICAL DISTRIBUTION IN THE SOIL

To determine the vertical distribution of cysts, adult females,

FIG. 5.7 : AVERAGE PERCENTAGE MORTALITY PER VINE OF CYSTS (ALL SIZES) OF M. CAPENSIS FROM OCTOBER 1974 TO SEPTEMBER 1975 IN MALMESBURY

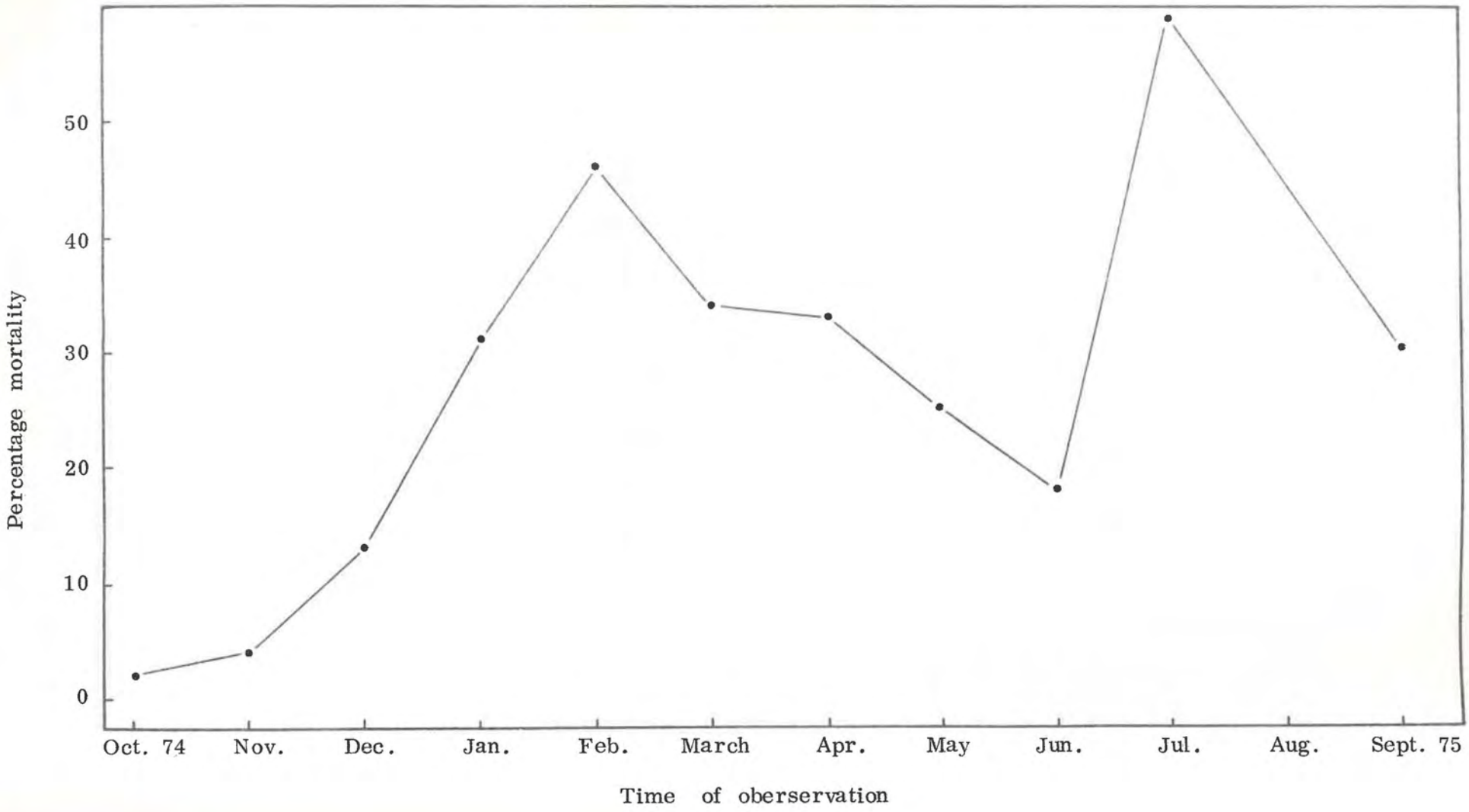
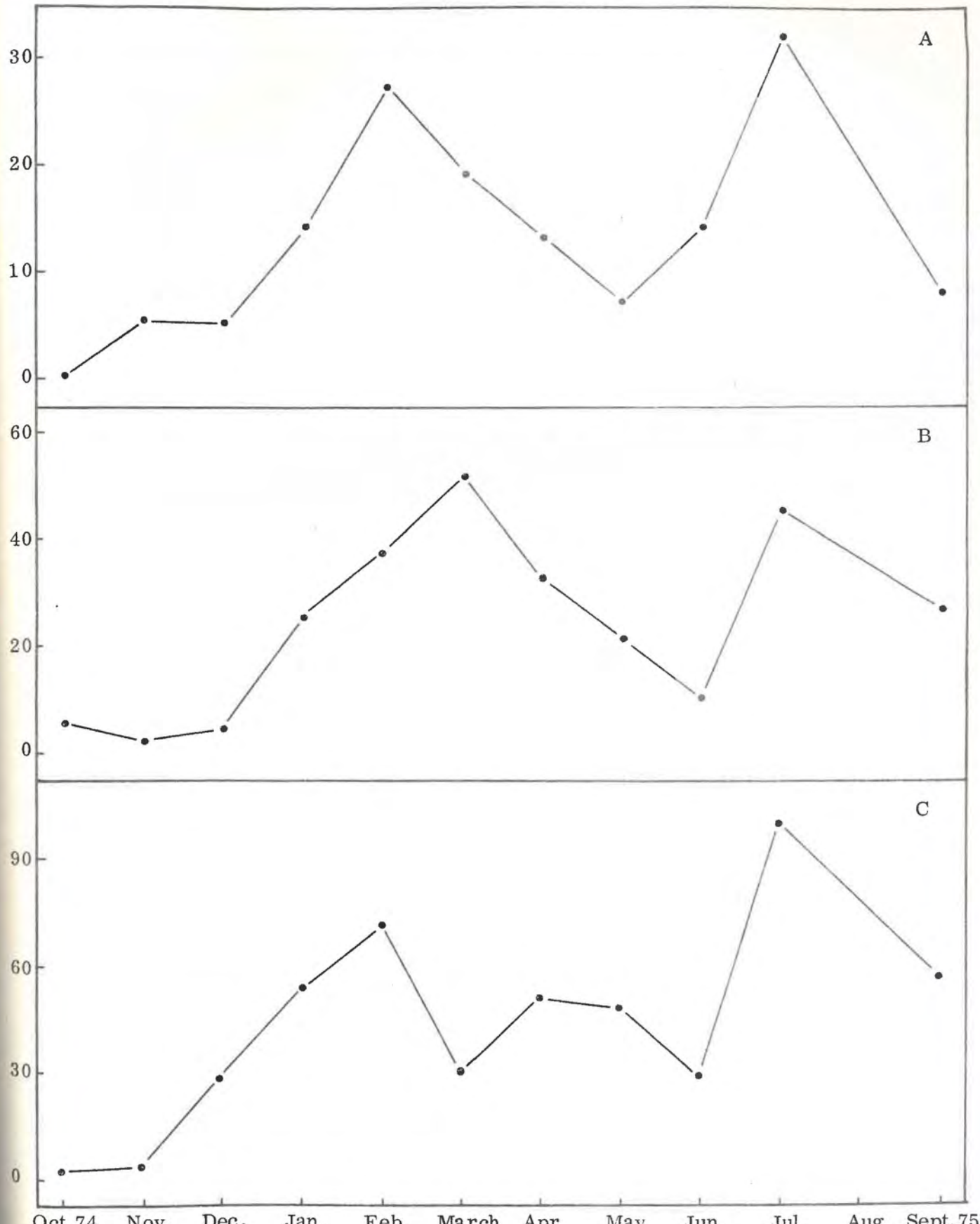


FIG. 5.8 : AVERAGE PERCENTAGE MORTALITY PER VINE OF CYSTS (A) GREATER THAN 2,8 MM, (B) 2,8 - 2,0 MM AND (C) 2,0 - 1,0 MM IN DIAMETER OF M. CAPENSIS FROM OCTOBER 1974 TO SEPTEMBER 1975 IN MALMESBURY



eggs and first instar larvae, the total number found at each vine and at each date of observation was counted for each of the eight layers of soil (par. 5.1) down to a depth of 1,2 m. The number of vines and observation dates concerned are mentioned in the following paragraphs.

In addition a number of physical factors were measured for each layer and comparisons made of the distribution of the cysts and variation in the physical factors through the different layers. These comparisons could, however, not be statistically analysed because the number of cysts and the physical factors were not always made at the same vines and at the same observation dates.

5.4.1 VERTICAL DISTRIBUTION OF CYSTS

The average number of cysts of all sizes per vine at the various depths is shown in Figure 5.9. The population of cysts was at a very low level in the first 15 cm of soil, increasing gradually to reach a peak at a depth of 46 - 60 cm. In the following layers it decreased again and at a depth of 91 - 120 cm, cysts occurred only in limited numbers. These results were obtained from observations throughout the whole year at a total of 21 vines.

As shown in Figure 5.10A and 5.10B the distribution in depth of cysts greater than 2,8 mm and cysts of the size range 2,8 - 2,0 mm were almost the same as that of cysts of all sizes together, with a peak at 46 - 60 cm. The number of cysts in the size range 2,0 - 1,0 did not form a distinct peak but was at a high level at a depth of 16 to 75 cm. At depths of 0 - 15 cm and 76 - 120 cm their numbers were low (Fig. 5.10C).

FIG. 5.9 : AVERAGE NUMBER OF CYSTS (ALL SIZES) PER VINE OF M. CAPENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 21 VINES.

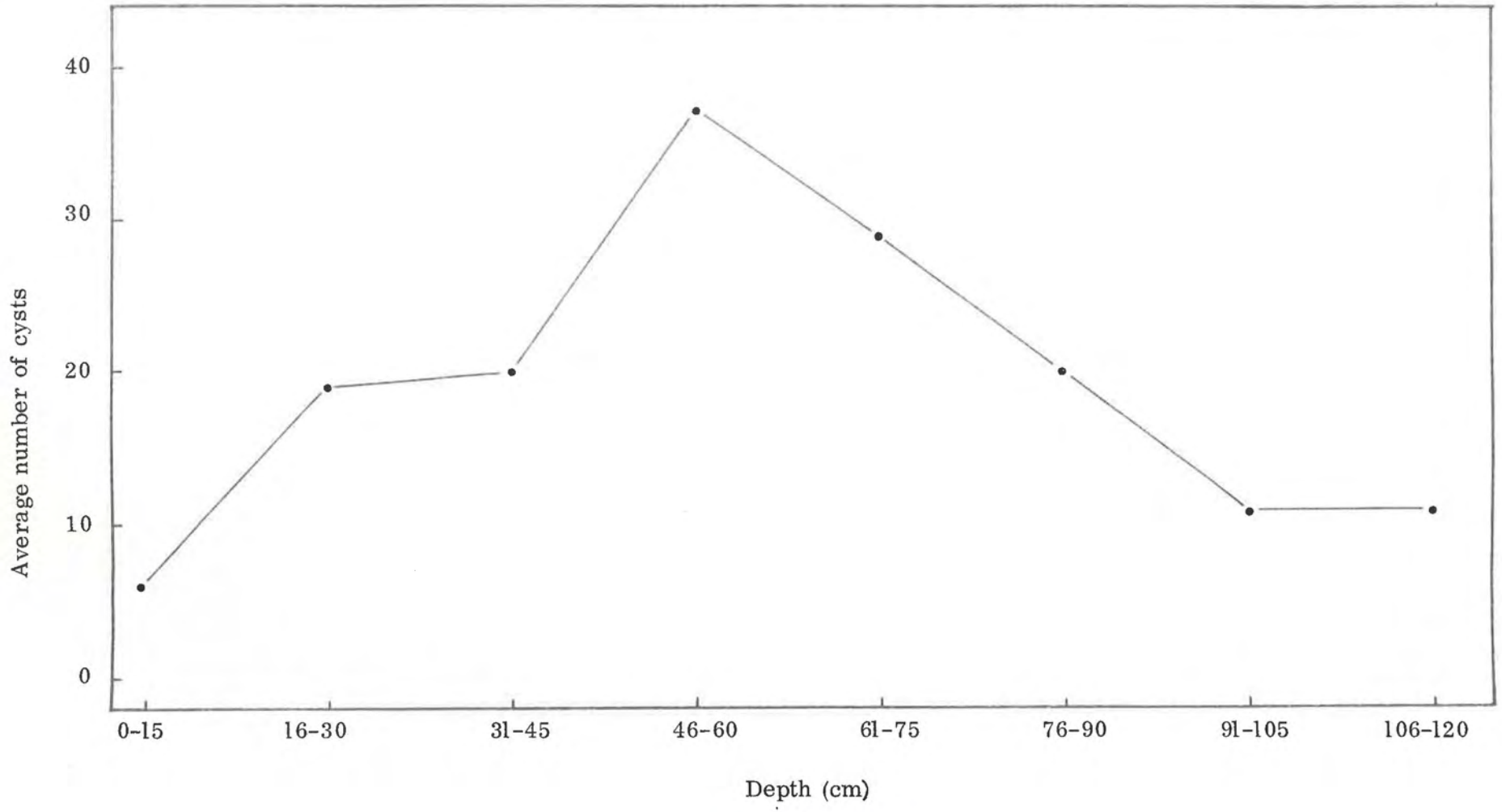
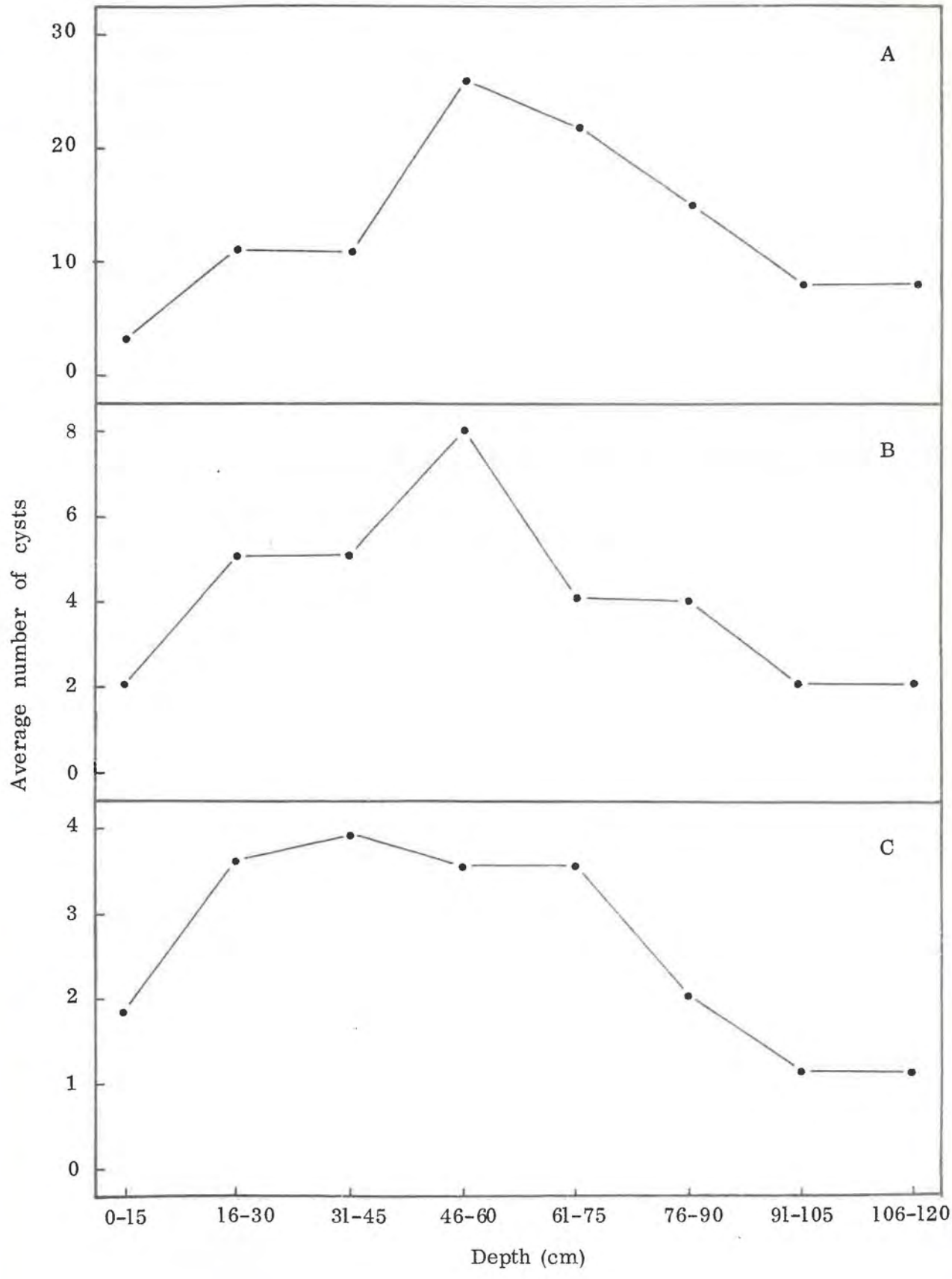


FIG. 5.10 : AVERAGE NUMBER OF CYSTS OF M. CAPENSIS PER VINE AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 21 VINES (A) CYSTS GREATER THAN 2,8 MM, (B) CYSTS 2,8 - 2,0 MM AND (C) CYSTS 2,0 - 1,0 MM IN DIAMETER.



The percentage soil moisture content at 12 vines and on different dates of observation throughout the year was calculated for each of the eight layers of soil to a depth of 1,2 m. The average percentage soil moisture content per vine at the various depths is shown in Figure 5.11. A comparison between Figures 5.9 and 5.11 shows that the average number of cysts was low at a depth of 0 - 15 cm where the average percentage soil moisture was also low. At a depth of 106 - 120 cm where the soil moisture was at its highest, the number of cysts was again very low. This indicates that as far as moisture content is concerned the occurrence of cysts is possibly inhibited by very dry as well as very wet soil conditions. As the average percentage soil moisture was almost the same at each of the various depths between 16 and 105 cm, the peak in the occurrence of cysts at a depth of 46 - 60 cm could thus not be attributed to the influence of soil moisture.

To examine the relationship between cyst and root distribution four vines were chosen at random during January 1975 and the root mass of each vine and at each of the eight layers of soil down to a depth of 1,2 m were determined. The average root mass per vine at the various depths is shown in Figure 5.12. At a depth of 0 - 15 cm and at 91 - 120 cm the root mass were very low. This could be the result of too dry or too wet soil conditions as shown in Figure 5.11. The reduced root mass could thus be a direct factor influencing the low number of cysts at these depths as shown in Figure 5.9. The highest number of cysts occurred at the same depth (16 to 90 cm) in which the root mass was the highest. However, the two are not directly related as indicated by the fact that

FIG. 5.11 : AVERAGE PERCENTAGE SOIL MOISTURE CONTENT PER VINE AT VARIOUS DEPTHS TO 1,2 M SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 12 VINES.

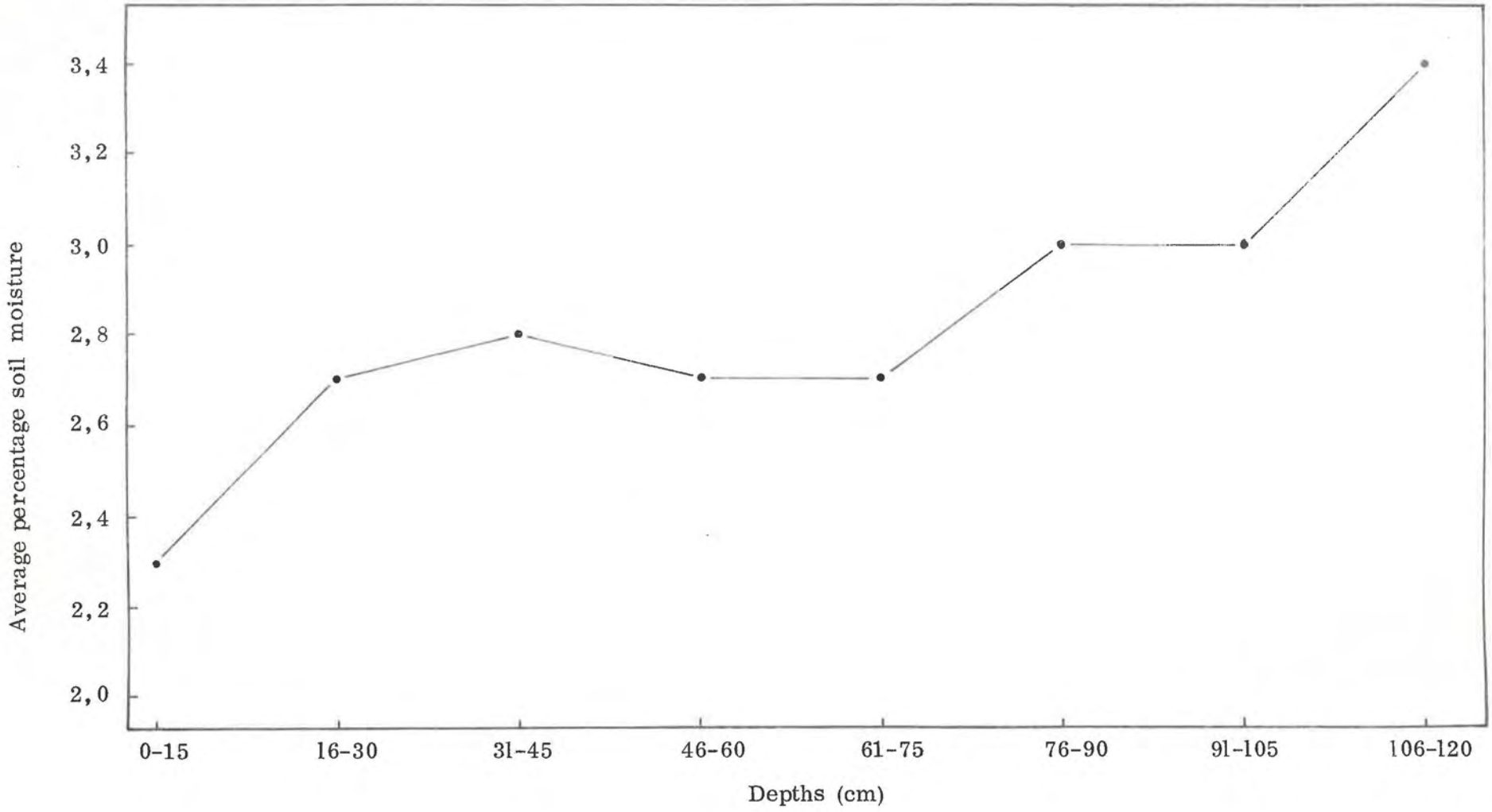
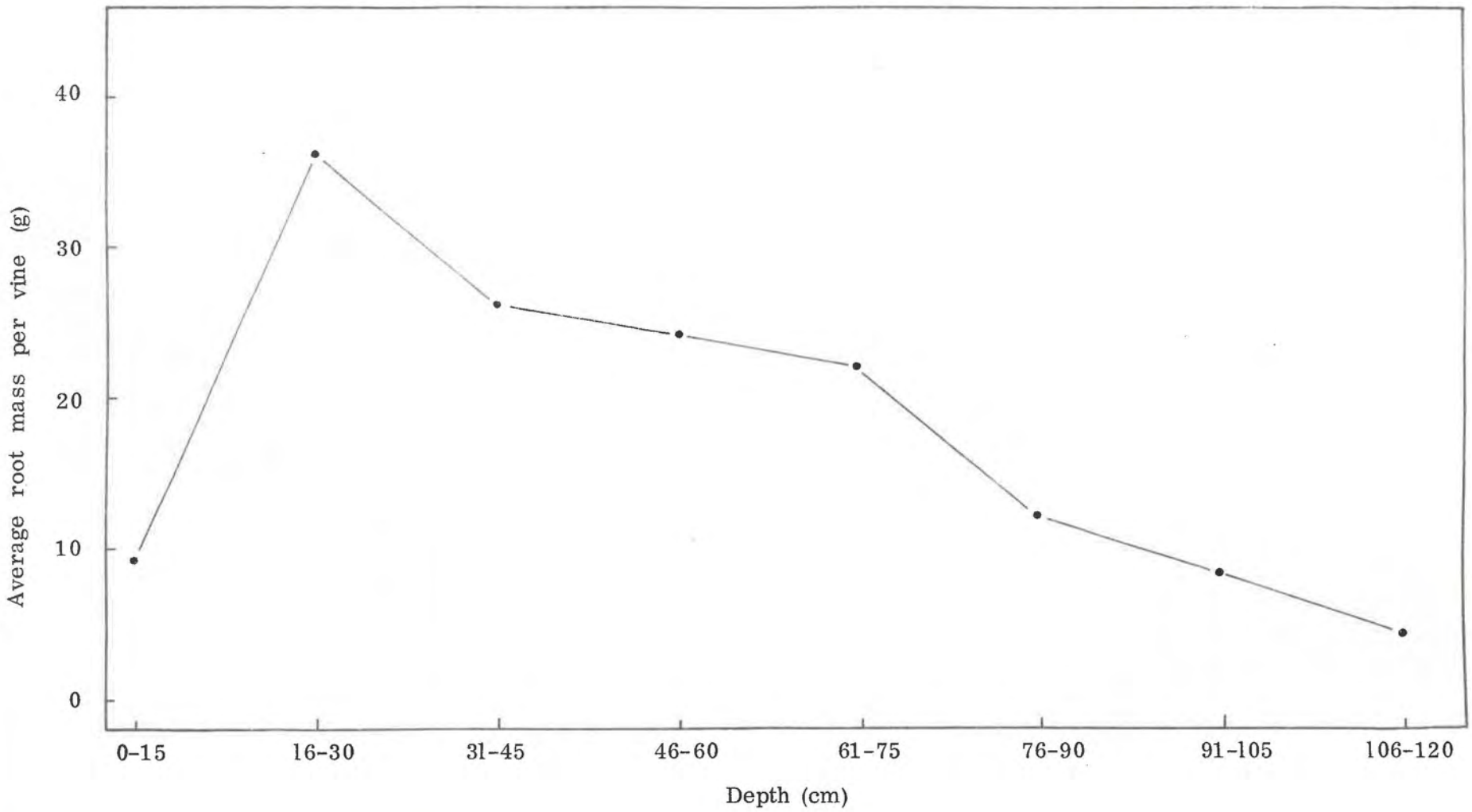


FIG. 5.12 : AVERAGE ROOT MASS PER VINE AT VARIOUS DEPTHS TO 1,2 M SAMPLED IN MALMESBURY DURING JANUARY 1975 AT FOUR VINES.



the peaks in root mass and cysts did not coincide.

At each of these four vines a soil sample was taken at each depth down to 1,2 m. The soil at each depth was bulked and analysed by the soil science section of the Viticultural and Oenological Research Institute according to the hydrometer method of Day (1956). The percentage coarse sand (2,0 - 0,5), medium sand (0,5 - 0,21 mm), fine sand (0,21 - 0,02 mm), silt (0,02 - 0,002 mm) and clay (<0,002 mm) of each sample were determined, and the results are shown in Figure 5.13. The percentage coarse sand increased slightly from 0 to 75 cm and in the following layers it decreased slightly, showing a different distribution pattern from those of the cysts. The percentage coarse sand could thus not be the direct cause of the vertical distribution pattern of cysts shown in Figure 5.9. As shown in Figure 5.13, the percentage medium sand, fine sand and silt were respectively almost at the same level in each layer of soil, while the percentage clay increased gradually to a depth of 1,2 m. The vertical distribution of cysts appears not to be influenced by these soil fractions.

The percentage dead cysts (par. 5.3) of each of the three size ranges and at each of the various depths was determined. As the figures for the different size ranges were almost similar, cysts of all sizes were taken together and their mortality at different depths compared. The results are shown in Figure 5.14. No definite peak occurred, indicating that the normal mortality of cysts is at the same level from 0 to 1,2 m in the soil. Results were obtained from observations throughout the whole year at a total of 21 vines.

FIG. 5.13 : PERCENTAGE COARSE SAND, MEDIUM SAND, FINE SAND, SILT AND CLAY AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M IN MALMESBURY

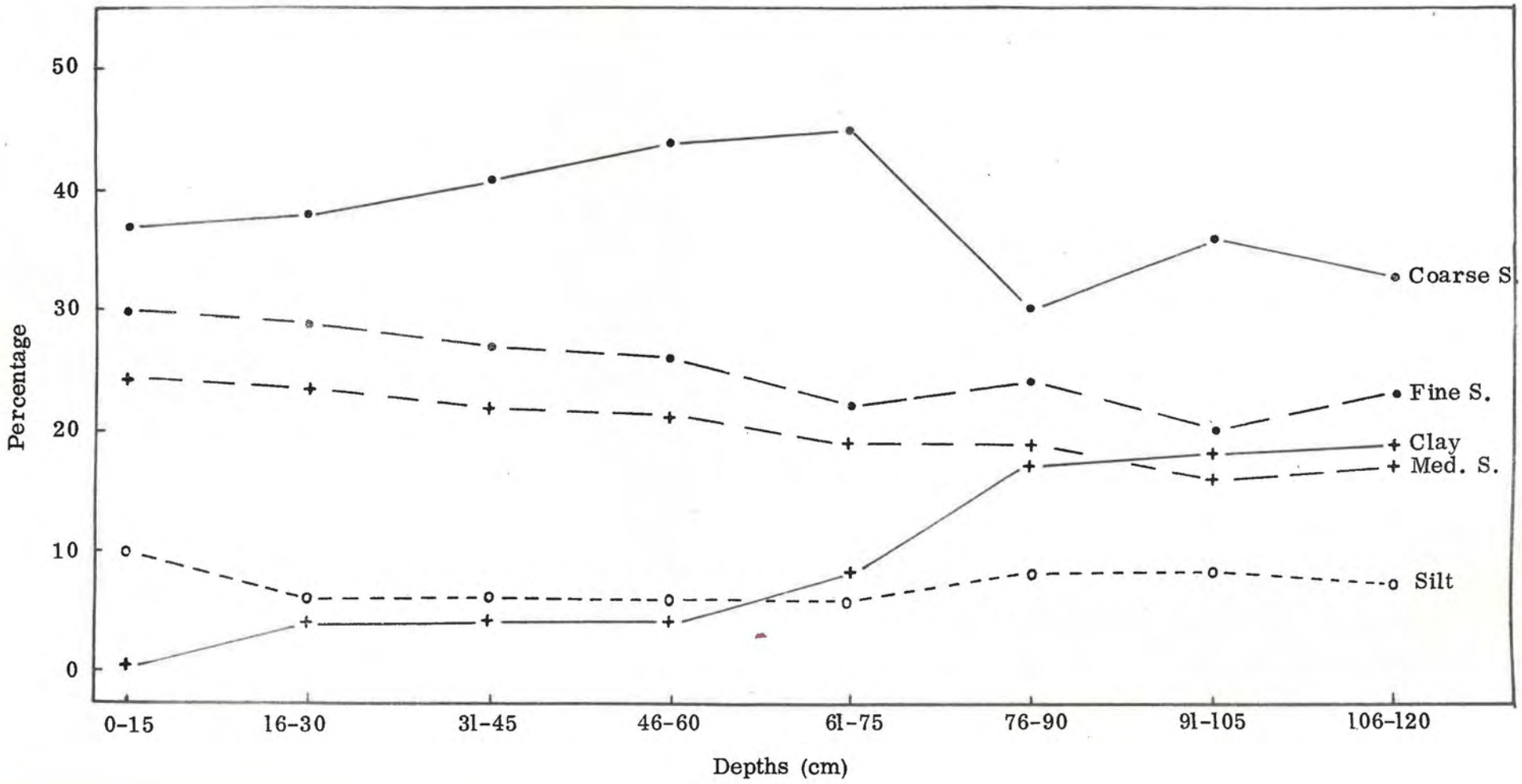
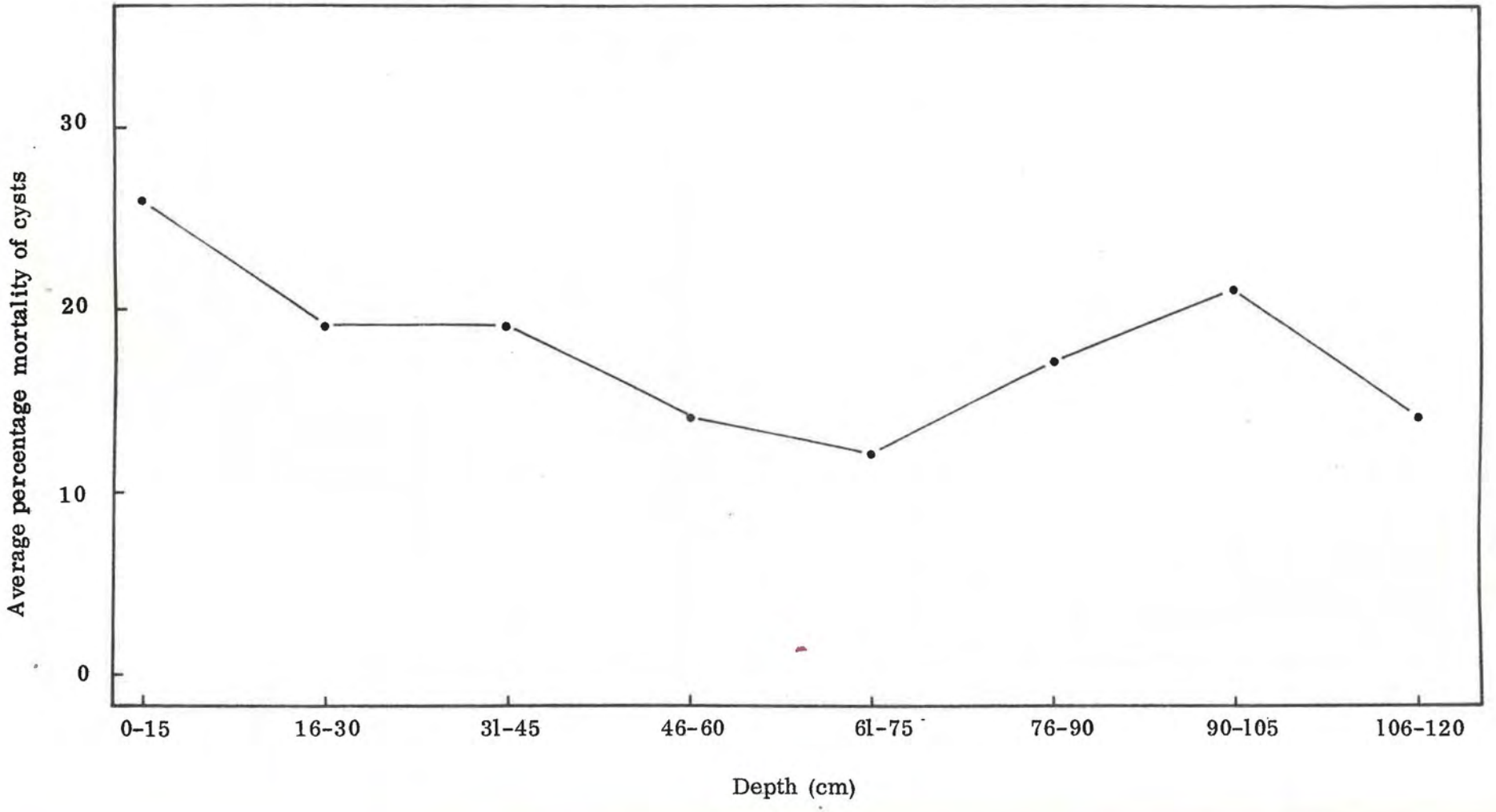


FIG. 5.14 : AVERAGE PERCENTAGE MORTALITY PER VINE OF CYSTS (ALL SIZES) OF M. CAPENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M IN MALMESBURY.



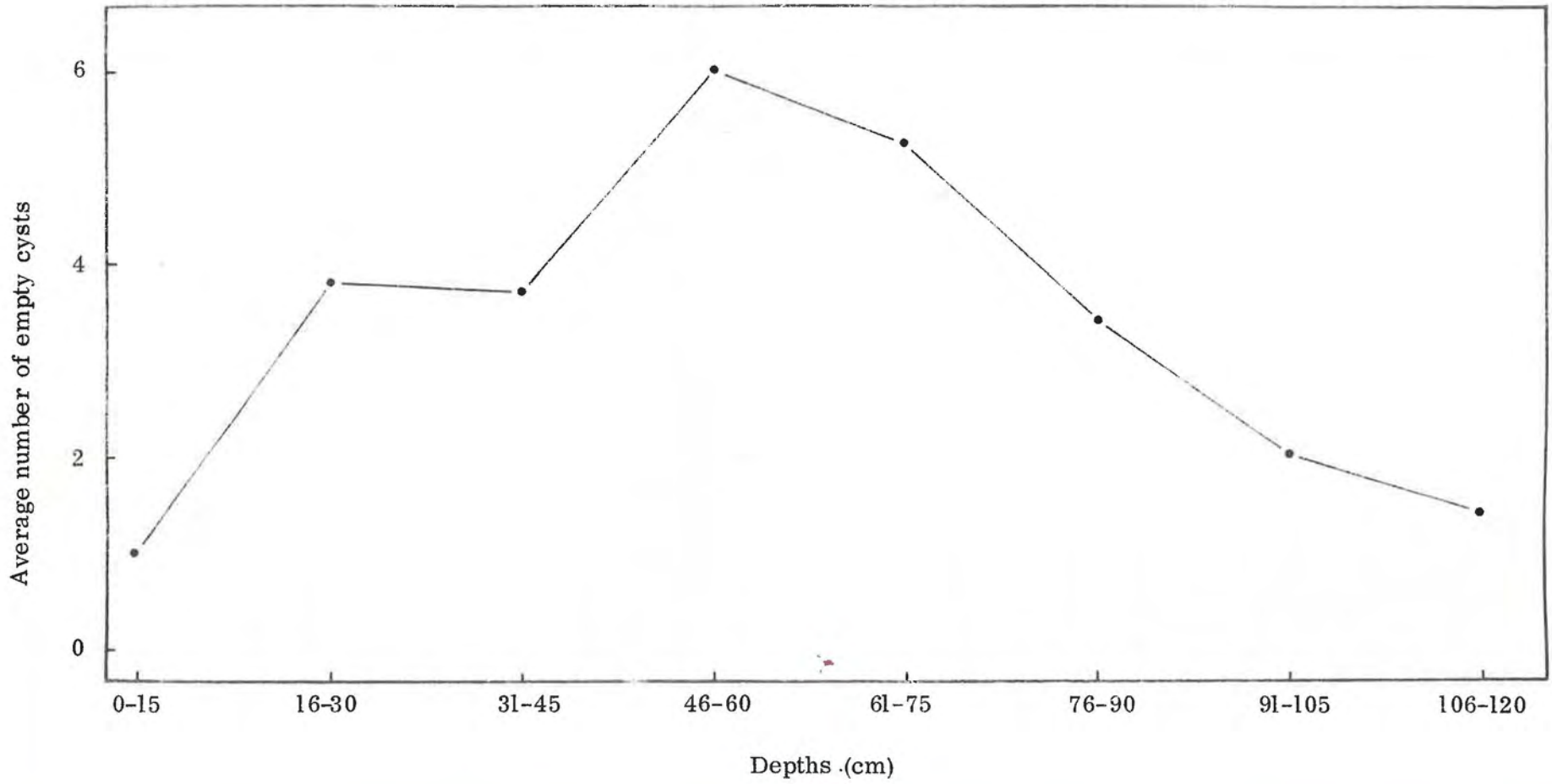
5.4.2 VERTICAL DISTRIBUTION OF EMPTY CYSTS

The average number of empty cysts in the size range greater than 2,8 mm per vine at various depths in the soil is shown in Figure 5.15. Results were obtained throughout the whole year from a total of 21 vines. Empty cysts occurred in very low numbers in the first 15 cm of soil, their numbers increasing gradually to a peak at a depth of 46 - 60 cm. In the following layers their numbers decreased again and at a depth of 120 cm it was again at a very low level. A comparison between Figure 5.9 and 5.15 shows clearly that the vertical distribution of live cysts and that of empty cysts followed almost exactly the same pattern. The occurrence of empty cysts is thus directly influenced by the occurrence of live cysts.

5.4.3 VERTICAL DISTRIBUTION OF ADULT FEMALES, EGGS AND FIRST INSTAR LARVAE

The total number of adult females, obtained during their time of occurrence at 18 vines and at various depths in the soil is shown in Figure 5.16A. The females occurred in low numbers in the upper 15 cm of soil, but are more abundant at a depth of 16 - 30 cm. In the deeper layers their numbers decreased gradually with depth and at a depth of 106 - 120 cm, females were absent. From these results it is clear that the females occur at any depth to 1,05 m in the soil and that the highest numbers are found between 16 and 75 cm. The low number of females in the upper 15 cm and again at a depth of 76 - 120 cm could be related to the low numbers of live cysts found at these depths (Fig. 5.9). As shown in Figure 5.15, the number of empty cysts was actually very low at these depths.

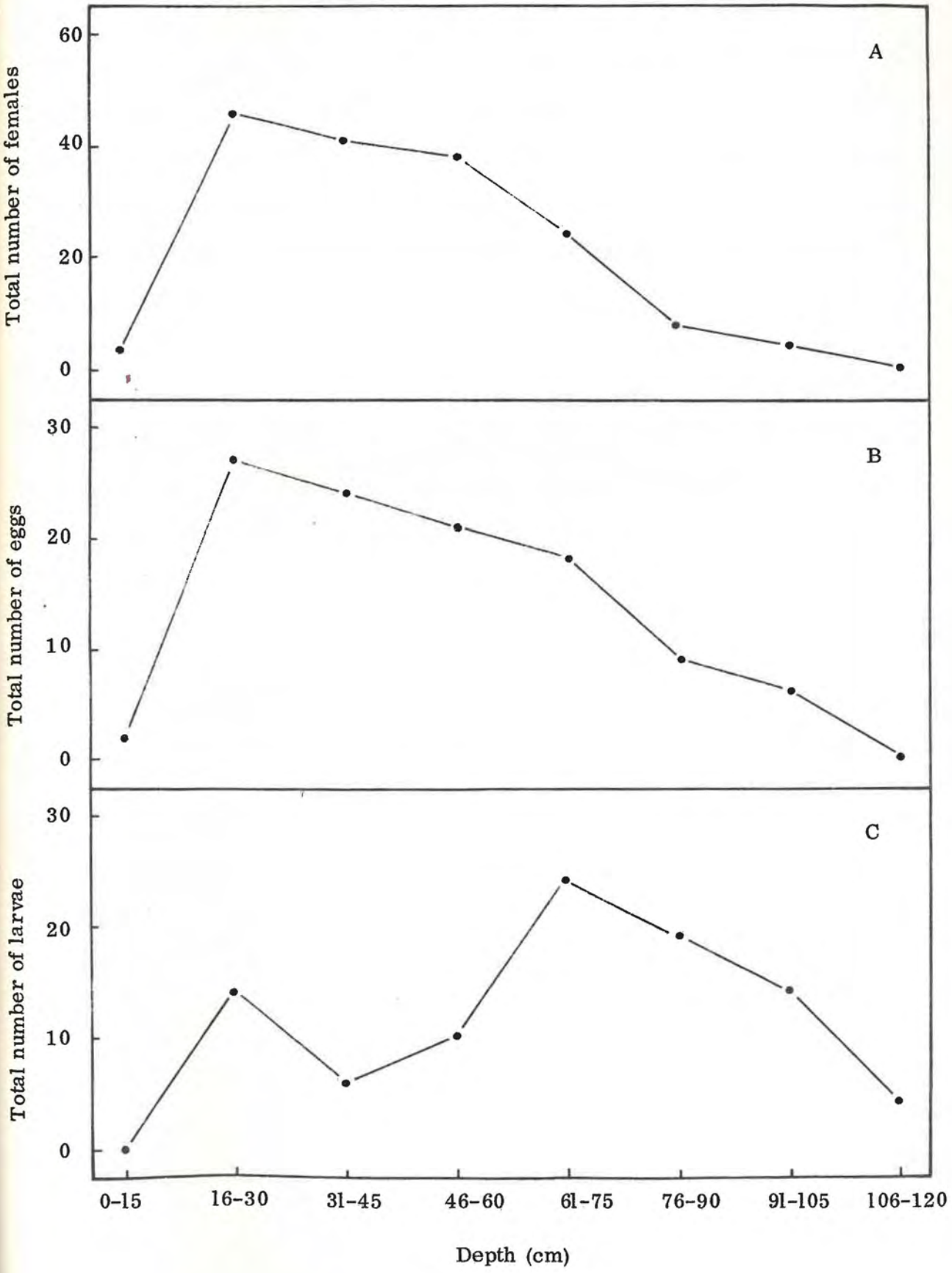
FIG. 5.15 : AVERAGE NUMBER OF EMPTY CYSTS GREATER THAN 2,8 MM IN DIAMETER PER VINE OF M. CAPENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN MALMESBURY FROM OCTOBER 1974 TO SEPTEMBER 1975 AT 21 VINES.



The moisture content of the soil was very low in the upper 15 cm, but very high at a depth of 76 - 120 cm (Fig. 5.11). Too dry and too wet soil conditions could thus also be a factor influencing the occurrence of the females. Although adult females do not feed, they have to deposit their eggs in the vicinity of roots to enable the small larvae to find nourishment easily. The low incidence of roots in the upper 15 cm as well as at a depth of 76 - 120 cm, could thus also be influencing the distribution of the females. A comparison between Figure 5.16A and Figure 5.12 shows that the vertical distribution of the females followed a very similar pattern to that of the roots. As shown in Figures 5.9 and 5.15, the highest number of live cysts and empty cysts occurred at a depth of 46 - 60 cm. The highest number of adult females, however, occurred at a depth of 16 - 30 cm. This indicates that the adults had migrated from a depth of 46 - 60 cm to a depth of 16 - 30 cm to reach an area with a higher distribution of roots. A comparison between Figure 5.16A and Figure 5.13 shows clearly that the vertical distribution of females was not influenced by the texture of the soil.

The total number of eggs, obtained during the egg laying period at 11 vines, and at various depths in the soil, is shown in Figure 5.16B. Eggs occurred in limited numbers in the upper 15 cm of the soil. Then their numbers increased rapidly, reaching a peak at a depth of 16 - 30 cm. In the lower layers their numbers decreased again gradually and at a depth of 106 - 120 cm eggs were absent. The vertical distribution of eggs is a result of the distribution of adult females that oviposited them and factors influencing the dis-

FIG. 5.16 : TOTAL NUMBER OF (A) ADULT FEMALES, (B) EGGS AND (C) FIRST INSTAR LARVAE OF M. CAPENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN MALMESBURY AT DIFFERENT VINES OVER THE TIME OF OCCURRENCE OF THESE STAGES.



6. BIOLOGY OF MARGARODES VREDENDALENSIS UNDER LABORATORY AND CONTROLLED CONDITIONS

6.1 MATERIAL AND METHODS

6.1.1 EMERGENCE OF ADULT FEMALES FROM CYSTS

To obtain cysts for laboratory observations, soil samples were taken at different vines in a heavily infested vineyard on the farm Liebendal near Vredendal in the Olifants River irrigation area, North Western Cape Province. In the laboratory the soil was washed through sieves with water. All the cysts were removed from the sieves and those with an emergence orifice (empty cysts) discarded. The remaining cysts were divided into live and dead cysts using the method as described under paragraph 4.1.1.

Live cysts of various sizes were kept and observed in the laboratory using the method as described for M. capensis under paragraph 4.1.1.

6.1.2 OVIPOSITION

Various aspects on oviposition (mentioned in the results) were observed on 29 females during January and February using the method as described for M. capensis under paragraph 4.1.2. The influence of temperature at a constant relative humidity as well as relative humidity and soil moisture on oviposition were also determined (par. 4.1.2). Procedures to determine the influence of temperature at a constant soil moisture on oviposition were as follows. Small glass tubes (2 cm in diameter and 6 cm deep) were each filled with 25 g air dried soil to which were added 3 cc water. Five tubes with one female

each were kept at each of 10, 25, 30 and 40°C. The original mass of each tube was kept constant by replacing evaporated water every second or third day. After one month the females were removed and the total number of eggs per female determined. The percentage moisture content of the soil, determined on a dry-mass basis, was 14 per cent.

6.1.3 INCUBATION OF EGGS

The influence of relative humidity, temperature at a constant relative humidity, soil moisture as well as temperature at a constant soil moisture content on the incubation of eggs, were determined according to the same procedures as described for M. capensis under paragraph 4.1.3.

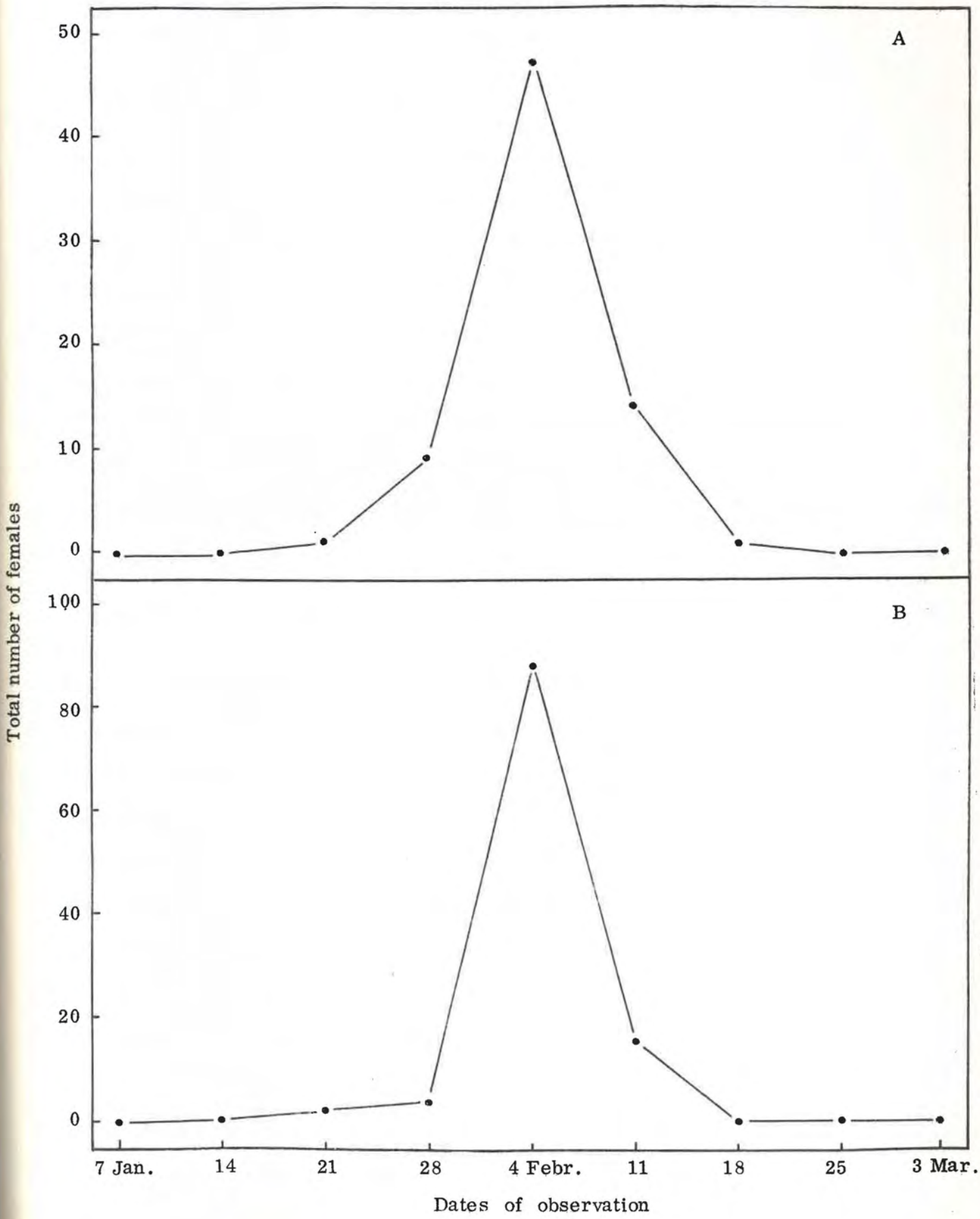
6.2 EMERGENCE OF ADULT FEMALES FROM CYSTS

6.2.1 TIME OF EMERGENCE

Cysts were collected at the vineyard in Vredendal during November 1974 and kept in the laboratory at room temperature and humidity. From a total of 669 cysts, 72 adult females emerged from 17 January to 12 February 1975. During the third week of January their numbers were very low. From the last week of January their numbers increased, reaching a peak during the first week of February. During the second and third week their numbers decreased again and from the end of February no emergence of females was observed (Fig. 6.1A).

The remaining cysts were kept in the laboratory and a total of 106 females emerged from 19 January to 11 February 1976, again reaching a peak during the first week of February (Fig. 6.1B). In this respect the life history of M. vredendalensis is in close agreement with that of M. capensis where adult females

FIG. 6.1 : TOTAL NUMBER OF ADULT FEMALES EMERGED FROM CYSTS OF M. VREDENDALENSIS ON VARIOUS DATES DURING (A) 1975 AND (B) 1976 UNDER LABORATORY CONDITIONS.



emerged from the end of November to the beginning of March, their numbers reaching a peak during the third week of January or at the middle of February (par. 4.2.1).

6.2.2 PERCENTAGE EMERGENCE

During February 1973, live cysts were collected in the vineyard at Vredendal and observed in the laboratory. Of these only 12,5 per cent developed into adult females during 1974. From a number of live cysts collected in the same vineyard during November 1974 and kept in the laboratory 10,8 per cent developed into adult females during 1975. Of the remaining cysts of this group 15,8 per cent developed into females during 1976.

These results show that only a small percentage of cysts develop into females annually. In M. capensis this percentage was only between 3 and 9 (par. 4.2.2).

6.2.3 EMERGENCE DURING SUCCESSIVE YEARS

The cysts collected during February 1973 and referred to in paragraph 6.2.2 were kept under laboratory conditions for a number of years. During January and February of 1974, 1975, 1976 and 1977 the percentage emergence of adult females from the original number of cysts was 12,5; 25,0; 12,5 and 6,3 respectively. At the end of this period the remaining cysts were opened to determine whether the nymphs were alive or not as indicated by the presence or absence of body fluid. Of the original number of cysts, 31,3 per cent was still alive after four years.

These results clearly indicate that adult females could still emerge four years after collection of cysts from a vineyard,

even if the cysts are detached from the roots and receive no nourishment. If an infested vineyard is replanted within four years, the new vineyard could thus still become infested from cysts that had developed on the original planting. Similar results were obtained with M. capensis (par. 4.2.3).

6.3 OVIPOSITION AND FECUNDITY

6.3.1 PRE-OVIPOSITION PERIOD

Under laboratory conditions the adult females were very active during the first two to four days after emergence from cysts, moving around and trying to burrow through the filter paper placed in the petri dishes. On reaching the edge, most of the females crawled underneath the paper. After this period of activity they became sedentary and only little movements of legs and abdomen were noticed. During the inactive period wax threads were excreted, first on the dorsal and ventral sides of the last abdominal segment, but two to three days later on all the abdominal segments. As oviposition proceeded, these wax threads became longer and denser to cover the whole body as well as the eggs.

The average period from emergence to the first appearance of wax threads was 11 days with a minimum and maximum of 6 and 15 days respectively. The average period of wax production before oviposition started, was 4 days with a minimum of 1 day and a maximum of 7 days. The pre-oviposition period thus lasted 15 days on average with a minimum and maximum of 10 and 20 days respectively (Table 6.1). In comparison, the pre-oviposition period of M. capensis lasted 9 days on average with a minimum and maximum of 4 and 15 days respectively (par. 4.3.1).

Since it is known that some species migrate to the soil surface for mating during the pre-oviposition period (Du Toit, 1975) the migration pattern of M. vredendalensis after emergence from the cysts, was investigated. Glass jars, 6 cm high and 4 cm in diameter, were each filled with moist soil and 30 females were placed individually on the soil surface in each container directly after emergence. Thirteen of these containers were kept in the laboratory and all the females burrowed immediately into the soil, not returning to the soil surface during the next 7 days. The other 17 jars were burrowed in a box of soil with their openings level with the soil surface and placed in direct sunlight from 08h00 to 17h00 daily. One of the females died without entering the soil, becoming brown and shrivelled after 8 hours. The rest of the females burrowed immediately into the soil, without returning to the soil surface. After 7 days the soil was removed and all the females were found at the bottom of the jars. Only 23,5 per cent of them were still alive. Females kept in the laboratory were also found at the bottom of the containers after 7 days, but 100 per cent were still alive.

The results show clearly that females do not stay at or migrate to the soil surface for mating and that normal summer temperatures could cause their death in the upper 6 cm of the soil. Experiments with M. capensis showed that adult females of this species also do not migrate to the soil surface for mating (par. 4.3.1).

6.3.2 OVIPOSITION PERIOD AND LONGEVITY OF FEMALES

As shown in Table 6.1 the average period of oviposition was 18 days with a minimum and maximum of 5 and 30 days respec-

tively. In comparison, the oviposition period of M. capensis lasted 11 days on average with a minimum of 5 days and a maximum of 18 days (par. 4.3.2).

The period from the end of oviposition to the death of the females was on average 6 days with a minimum and maximum duration of 3 and 13 days respectively. The average longevity of adult females was 40 days with a minimum and maximum of 27 and 49 days respectively (Table 6.1). The average longevity of adult females of M. vredendalensis is thus considerably longer than that of M. capensis which is only 24 days (par. 4.3.2).

6.3.3 FECUNDITY

When the female oviposits in the soil, eggs are laid in a bundle and covered with wax threads to form a compact egg sack. In an open space such as in a petri dish, however, the eggs are laid attached to one another forming a string of eggs, covered with wax threads. Up to 139 eggs were counted in a single string. The total number of eggs per female averaged 507 with a minimum of 164 and a maximum of 1 238 (Table 6.1). Fecundity in M. vredendalensis is thus considerably higher than in M. capensis in which the total number of eggs per female averaged only 251 with a minimum and maximum of 33 and 539 respectively (par.4.3.3).

6.3.4 RATE OF OVIPOSITION

The lowest oviposition per female per day varied between 1 and 23 with an average of 3. The maximum varied between 30 and 185 with an average of 84. The average oviposition per female per day varied between 8 and 73 with an average of 30 (Table 6.1). This is more than in M. capensis in which the average

TABLE 6.1 : PRE-OVIPOSITION PERIOD, OVIPOSITION PERIOD, LONGEVITY, TOTAL NUMBER OF EGGS PER FEMALE AND NUMBER OF EGGS PER FEMALE PER DAY OF MARGARODES VREDENDALENSIS UNDER LABORATORY CONDITIONS

Replicates	Duration from emergence to formation of wax threads (days)	Duration from formation of wax threads to commencement of oviposition (days)	Duration from emergence to commencement of oviposition (days)	Oviposition period (days)	Duration after egg laying until death of female (days)	Longevity of adult female (days)	Total number of eggs per female	Minimum number of eggs per female per day	Average number of eggs per female per day	Maximum number of eggs per female per day
1.	13	4	17	17	9	43	814	3	48	134
2.	11	4	15	19	4	38	694	1	37	100
3.	13	2	15	20	8	43	1121	3	56	169
4.	11	1	12	17	8	37	1238	5	73	185
5.	10	3	13	16	8	37	1136	1	71	164
6.	11	4	15	16	5	46	313	2	20	59
7.	11	2	13	16	8	37	599	3	37	100
8.	9	4	13	16	7	46	913	2	57	127
9.	11	3	14	14	7	35	392	1	28	70
10.	10	4	14	14	7	35	406	4	29	88
11.	14	2	16	30	3	49	883	1	29	139
12.	11	6	17	16	7	40	164	2	10	30
13.	6	4	10	13	5	28	368	2	28	74
14.	9	4	13	18	7	38	397	2	22	67
15.	12	4	16	21	5	42	443	3	21	68
16.	14	5	19	23	6	48	403	1	18	63
17.	9	4	13	9	5	27	254	5	28	61
18.	9	3	12	5	13	30	212	23	42	71
19.	9	2	11	12	7	30	326	5	27	52
20.	13	4	17	25	6	48	329	2	13	49
21.	15	3	18	13	7	38	681	6	52	118
22.	14	5	19	23	6	48	248	2	11	50
23.	15	5	20	23	5	48	227	1	10	30
24.	9	5	14	14	6	34	193	1	14	49
25.	11	4	15	24	5	44	450	1	19	84
26.	13	5	18	23	6	47	306	2	13	53
27.	12	5	17	24	6	47	675	2	28	78
28.	12	7	19	24	4	47	200	1	8	34
29.	10	4	14	24	6	44	321	1	13	71
Average	11	4	15	18	6	40	437	2	29	88

was only 23 (par. 4.3.4).

The number of eggs per female per day for 29 females was determined. The average of each successive day during the oviposition period is shown in Figure 6.2. On the first day of oviposition the average number of eggs per female was relatively high, increasing gradually to reach a peak on the fifth day. Afterwards the production of eggs decreased and from the 25th day, no eggs were oviposited. Eighty six per cent of the total production was oviposited during the first 9 days.

6.3.5 NUMBER OF EGGS WITH REGARD TO THE SIZE OF THE FEMALE

The length and width of 29 adult females were measured just before commencement of oviposition and an index value for size was obtained for each female by multiplying its length by its width. The relationship between body size and fecundity was determined by calculating a linear regression coefficient. A highly significant ($P<0,01$) correlation was found ($r=0,8105$). As shown in Figure 6.3A the total number of eggs per female is positively correlated with the size of the female ($y=266,59 + 33,48x$).

A highly significant ($P<0,01$) positive correlation $r=0,6906$; $y= -8,62 + 1,70x$ (Fig. 6.3B) was also found between the body size of females and the average number of eggs per female per day.

6.3.6 INFLUENCE OF TEMPERATURE AT A CONSTANT RELATIVE HUMIDITY

Four desiccators, each with a constant relative humidity of

FIG. 6.2 : AVERAGE NUMBER OF EGGS OVIPOSITED PER FEMALE PER DAY BY M. VREDENDALENSIS UNDER LABORATORY CONDITIONS.

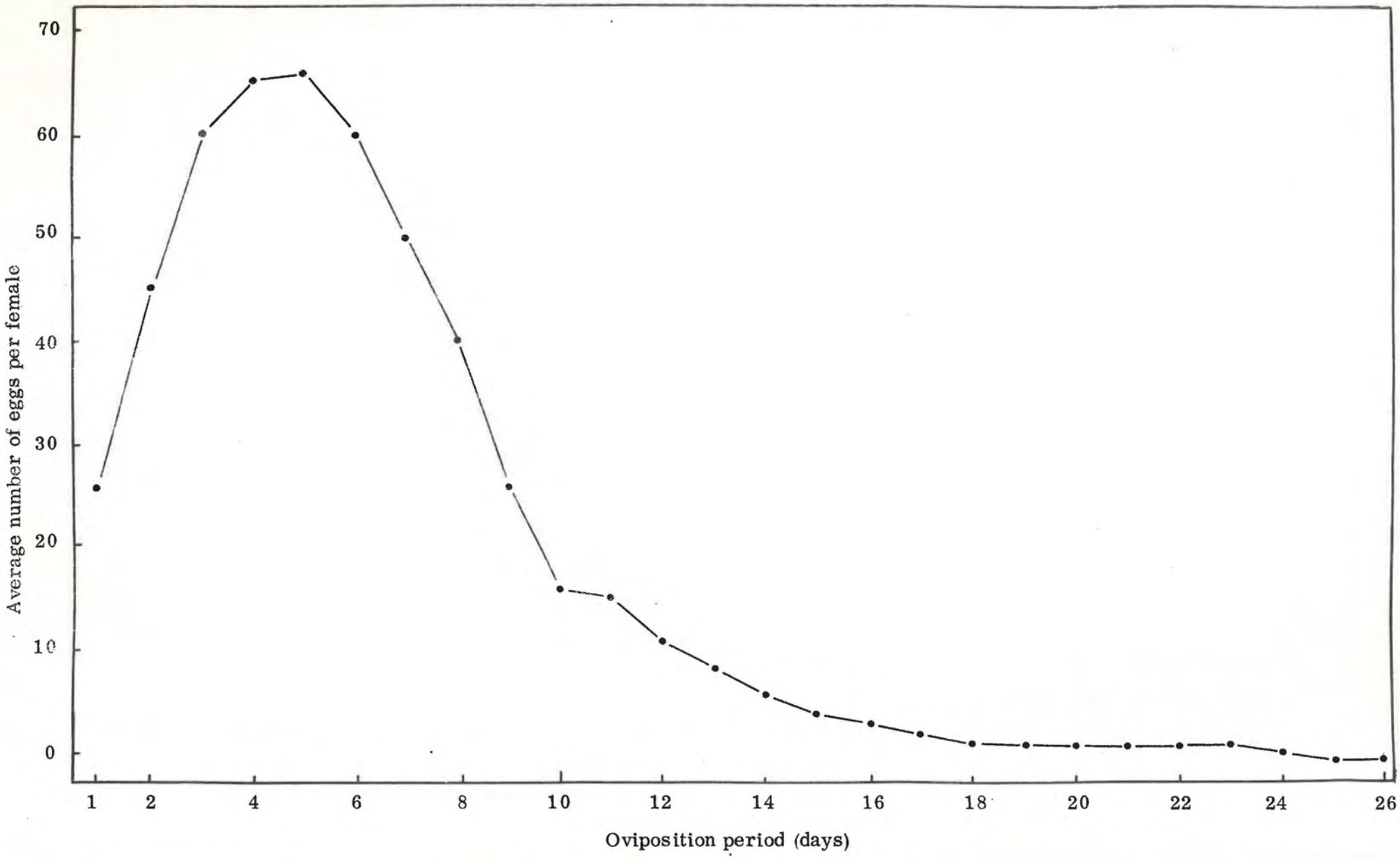
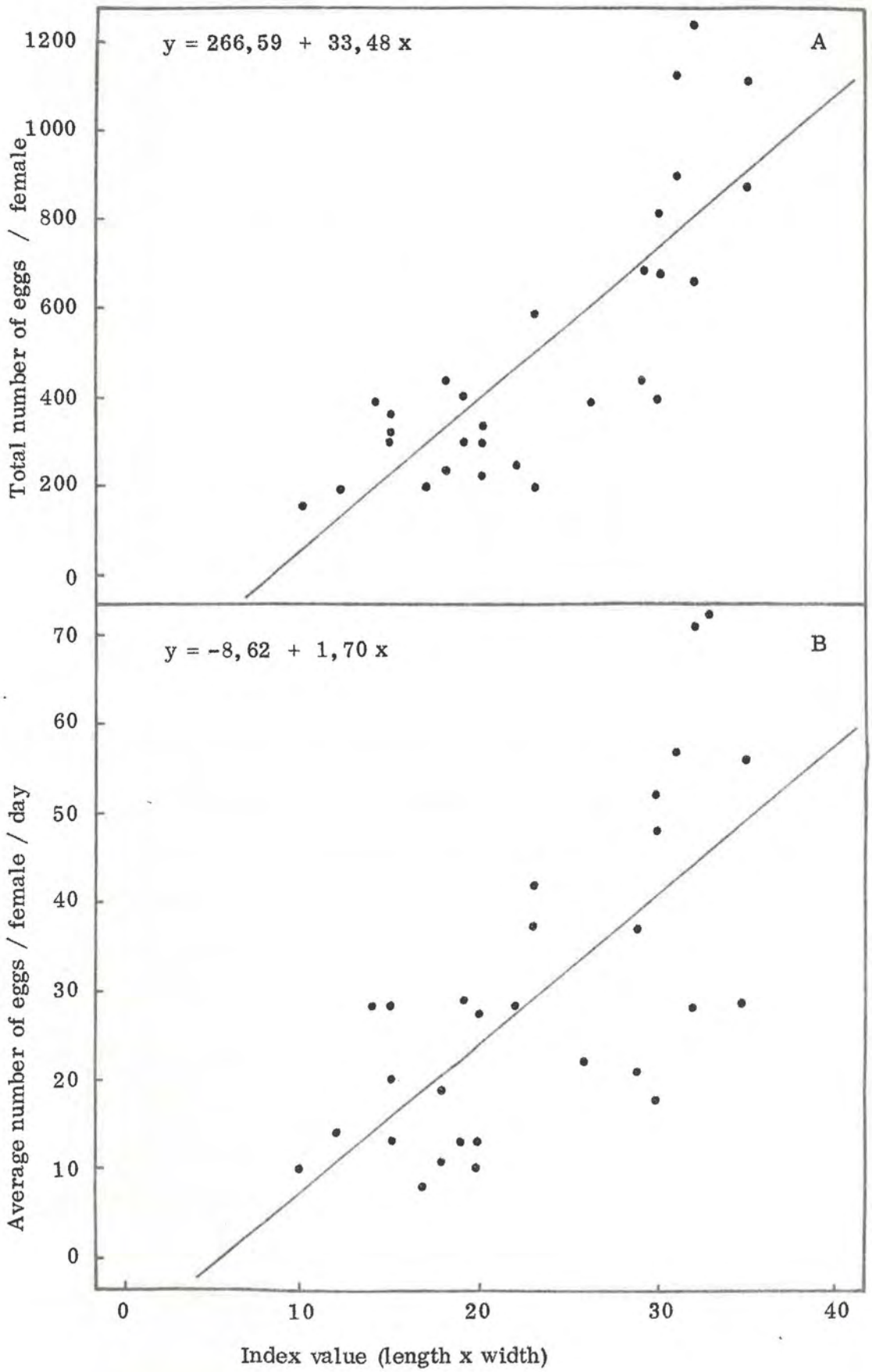


FIG. 6.3 : SCATTER DIAGRAM OF SIZE INDEX OF ADULT FEMALES OF M. VREDENDALENSIS TO (A) TOTAL NUMBER OF EGGS OVIPOSITED PER FEMALE AND (B) AVERAGE NUMBER OF EGGS OVIPOSITED PER FEMALE PER DAY.



75,5 per cent and containing six females were kept individually at 10, 25, 30 and 40°C. After a period of one month the total number of eggs per female was determined and the results are shown in Table 6.2.

Table 6.2 : Total number of eggs oviposited by females of M. vredendalensis at different temperatures and a constant relative humidity.

	Temperature			
Replicate	10°C	25°C	30°C	40°C
1	0	185	227	0
2	0	521	120	0
3	0	369	456	0
4	0	576	700	0
5	0	580	993	0
6	0	886	1054	0
Average	0	520	592	0

As shown in Table 6.2, a temperature of 10°C was evidently too low for the production of eggs. However, all the females kept at this temperature were still alive after one month. They were then transferred to room temperature and after 14 days, normal oviposition commenced. Although females are thus not killed at 10°C, egg production is inhibited. A temperature of 40°C was too high for egg laying and all the females were dead after one month. As shown in Table 6.2, eggs were produced normally by females kept at constant temperatures of 25 and 30°C and an analysis of variance showed no significant differences at the 5% level (F=0,1508). Similar results were obtained with females of

M. capensis kept at the same temperatures (par. 4.3.6).

6.3.7 INFLUENCE OF TEMPERATURE AT A CONSTANT SOIL MOISTURE

Five glass tubes (par. 6.1.2), with one female in each, were kept at each of 10; 25; 30 and 40°C. A constant soil moisture content of 14 per cent was kept in each tube. After a period of one month the total number of eggs per female was determined. The results are shown in Table 6.3.

Table 6.3 : Total number of eggs oviposited by females of M. vredendalensis at different temperatures and a constant soil moisture content.

	Temperature			
Replicate	10°C	25°C	30°C	40°C
1	0	288	216	0
2	0	-	204	0
3	0	116	-	0
4	0	382	428	0
5	0	305	335	0
Average	0	273	296	0

As shown in Table 6.3, temperatures of 10 and 40°C were too low and too high respectively for the production of eggs. However, eggs were oviposited normally at temperatures of 25 and 30°C. An analysis of variance showed no difference at the 5% level between these two treatments (F=0,0887). These results show a similar pattern to those obtained with the same temperatures at a constant relative humidity of 75,5 per cent (par. 6.3.6).

6.3.8 INFLUENCE OF RELATIVE HUMIDITY

Two desiccators with constant relative humidities of 32,5 and 75,5 per cent respectively and each containing six females, were kept at a constant temperature of 25°C. After a period of one month the total number of eggs per female was determined and the results are shown in Table 6.4.

Table 6.4 : Total number of eggs oviposited by females of M. vredendalensis at different relative humidities and a constant temperature.

Replicate	Relative humidity 32,5 %	75,5 %
1	101	185
2	164	521
3	106	369
4	149	576
5	107	580
6	315	886
Average	157	520

These results show clearly that oviposition took place normally at the different relative humidities tested. An analysis of variance, however, showed a highly significant ($P<0,01$) difference between the two treatments ($F=12,7566$). A relative humidity of 32,5 per cent thus has a detrimental influence on the production of eggs. Contradictory to this, no statistical difference could be found in the production of eggs by females of M. capensis at these two relative humidities (par. 4.3.7).

6.3.9 INFLUENCE OF SOIL MOISTURE

Females were kept in glass tubes filled with soil of which the

moisture content was kept constant at 2, 6, 10, 14, 22 and 30 per cent respectively at a constant temperature of 25°C. The field-capacity and saturation percentage of the soil were 20 and 32 per cent respectively. The total number of eggs per female at each treatment is shown in Table 6.5.

Table 6.5.: Total number of eggs oviposited by females of M. vredendalensis at different percentages soil moisture and a constant temperature.

	Percentage soil moisture					
Replicate	2	6	10	14	22	30
1	0	839	539	672	1114	815
2	0	376	721	322	308	479
3	0	445	464	377	523	325
4	60	426	867	563	396	223
Average	15	522	648	484	585	460

The results show clearly that oviposition occurred over a wide range of soil moisture conditions. Eggs were laid in dry soil with a moisture content as low as 2 per cent as well as in wet soil with a moisture content of 30 per cent. Oviposition was not inhibited when the percentage soil moisture exceeded that at field-capacity and eggs were laid even when it was very near the saturation percentage.

As analysis of variance of these results showed that significant ($P<0,05$) differences occurred between the treatments ($F=3,9812$). Tuckey's test of D-values indicated that the number of eggs produced at 2 per cent soil moisture differed from those of the other treatments. No other differences could be detected. Oviposition is thus not totally inhibited by low

soil moisture but the number of eggs produced at 2 per cent soil moisture could be considerably lower than that at percentages varying from 6 to 30 per cent. Similar results were obtained with females of M. capensis kept under the same conditions (par. 4.3.8).

6.4 INCUBATION OF EGGS

6.4.1 INFLUENCE OF RELATIVE HUMIDITY

Three desiccators with constant relative humidities of 32,5; 75,5 and 100 per cent respectively and each containing 250 one day old eggs were kept at a constant temperature of 25°C. The emerging larvae were counted and removed after 20, 34, 41, 48, 55 and 62 days respectively. The results are shown in Table 6.6A.

Table 6.6A : Total number of eggs of M. vredendalensis hatched at certain periods after oviposition at different relative humidities at 25°C (250 eggs per treatment).

Percentage humidity	Number of eggs					
	After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
32,5	0	0	0	0	0	0
75,5	0	0	0	0	0	0
100	0	0	95	2	0	0

As shown in Table 6.6A, the eggs did not hatch at relative humidities of 32,5 and 75,5 per cent, which were evidently too low. At a relative humidity of 100 per cent a number of eggs hatched

and the incubation period was longer than 35 but shorter than 48 days.

At each date of observation the number of live eggs was also counted. The figures shown in Table 6.6B are that of live plus ecloded eggs.

Table 6.6B : Total number of live and ecloded eggs of M. vredendalensis at certain periods after oviposition at different relative humidities and a constant temperature of 25°C (250 eggs per treatment).

Percentage humidities	Number of live and ecloded eggs					
	After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
32,5	235	70	44	18	0	0
75,5	181	20	0	0	0	0
100	236	213	138	17	9	0

The results show that only 28 and 8 per cent of the original number of eggs were still alive after 34 days at 32,5 and 75,5 per cent respectively.

These relative humidities were possibly too low for the normal development of eggs to larvae. At 100 per cent humidity, 85 per cent of the eggs were alive after 34 days while 55 per cent were still alive after 41 days. This indicates that the larvae develop normally in the eggs at a relative humidity of 100 per cent. The results on the influence of relative humidity on the eggs are in general agreement with those obtained for M. capensis (par. 4.4.1).

6.4.2 INFLUENCE OF TEMPERATURE AT A CONSTANT RELATIVE HUMIDITY

Four desiccators, each with a constant relative humidity of 100 per cent and containing 250 one day old eggs, were kept individually at 40, 30, 25 and 10°C. Larvae were counted and removed after 20, 34, 41, 48, 55 and 62 days respectively. The results are shown in Table 6.7A.

Table 6.7A : Total number of eggs of M. vredendalensis hatched at certain periods after oviposition at different temperatures and a constant relative humidity of 100 per cent (250 eggs per treatment).

Temperature °C	Number of eggs				
	After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
40	0	0	0	0	0
30	0	79	2	0	0
25	0	0	95	2	0
10	0	0	0	0	0

As indicated in Table 6.7A, eggs did not hatch at temperatures of 40 and 10°C, which were evidently too high and too low respectively. A number of eggs however, hatched at 30 and 25°C. The results indicate that the incubation period is possibly shorter at 30°C than at 25°C. The incubation period was more than 20 but shorter than 48 days.

The number of live eggs was counted after 20 and 34 days respectively. Afterwards it was counted at intervals of 7 days. The figures given in Table 6.7B are that of live and ecloded

eggs.

Table 6.7B : Total number of live and ecloded eggs of M. vredendalensis at certain periods after oviposition at different temperatures and a constant relative humidity of 100% (250 eggs per treatment).

Temperature °C	Number of live and ecloded eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days	After 62 days
40	0	0	0	0	0	0
30	222	150	41	22	5	0
25	236	213	138	17	9	0
10	239	197	174	120	86	62

The results show that all the eggs at 40°C were dead after 20 days, indicating that this temperature was too high for the normal development of eggs to larvae. At 10°C, 79 per cent of the original number of eggs were alive after 34 days and 25 per cent lived for 62 days. The eggs were eventually all dead after 76 days. A temperature of 10°C was therefore not fatal to the eggs, but it was evidently too low for their normal development. As shown in Table 6.7B, the total number of live eggs at 30°C after 34 days as well as after 41 days was considerably lower than that for the same periods at 25°C. An analysis of variance showed a significant ($P<0,05$) difference between the number of live eggs at 30 and 25°C after 34 days ($F=7,6474$) as well as after 41 days ($F=5,5592$). The influence of these temperatures at the same constant humidity on the incubation of eggs of M. capensis was generally the same as these results (par. 4.4.2).

6.4.3 INFLUENCE OF SOIL MOISTURE

The influence of soil moisture on the incubation of eggs was tested at 2, 10, 19, 27 and 35 per cent and at a constant temperature of 25°C. The field-capacity and saturation percentage of the soil were 20 and 32 per cent respectively. Observations were made on 60 one day old eggs per treatment. The number of larvae was determined after 20, 34, 41, 48 and 55 days respectively. The results are shown in Table 6.8A.

Table 6.8A : Total number of eggs of M. vredendalensis hatched at certain periods after oviposition at different percentages soil moisture and a constant temperature of 25°C (60 eggs per treatment).

Percentage soil moisture	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
2	0	0	0	0	0
10	0	0	2	0	0
19	0	0	1	0	0
27	0	0	6	0	0
35	0	0	19	1	0

Table 6.8A shows that eggs hatched at 10 to 35 per cent soil moisture but not at 2 per cent. An analysis of variance of the results showed that significant differences occurred between treatments at the 5% level (F=4,2099). Tuckey's test of D-values indicated that the number of larvae that hatched at 35 per cent soil moisture differed from that at the other percentages of soil moisture tested. No other statistical differences could be detected.

From these results it appears that hatching is inhibited under low soil moisture conditions. As shown in Table 6.8A, the incubation period was more than 34 but shorter than 48 days.

Dead eggs were also counted at each observation and the results are given in Table 6.8B.

Table 6.8B : Total number of dead eggs of M. vredendalensis out of 60 per treatment at certain periods after oviposition at different percentages soil moisture and a constant temperature (25°C).

Percentage soil moisture	Number of dead eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
2	38	60	-	-	-
10	33	44	53	58	-
19	44	49	57	59	-
27	33	47	50	52	54
35	15	25	30	40	-

Table 6.8B shows that all the eggs were dead after 34 days at a soil moisture content of 2 per cent, indicating that this was too low for the normal development of eggs to larvae. An analysis of variance of the numbers of dead eggs after 41 days at the various soil moistures, showed that significant ($P<0,05$) differences occurred between the treatments ($F=12,0259$). Tuckey's test of D-values indicated that the number of dead eggs at 35 per cent moisture content was significantly lower than at the other treatments. No other statistical differences could be detected. The results indicated that the mortality of eggs in wet soils is lower than that in dry soils. The

same general trend was observed in M. capensis, except that some eggs did hatch at a 2 per cent soil moisture content (par. 4.4.3).

6.4.4 INFLUENCE OF TEMPERATURE AT A CONSTANT SOIL MOISTURE

The influence of temperature on the incubation of eggs was tested at 10, 25, 30 and 40°C and at a constant soil moisture of 27 per cent. The field-capacity and saturation percentage of the soil were 20 and 32 per cent respectively. Observations were made with 75 one day old eggs per treatment and the number of emerging larvae was determined after 20 and 34 days respectively and thereafter at intervals of 7 days. The results are shown in Table 6.9A.

Table 6.9A : Total number of eggs of M. vredendalensis hatched at certain periods after oviposition at different temperatures and a constant soil moisture (75 eggs per treatment).

Temperature °C	Number of eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
10	0	0	0	0	0
20	0	2	5	5	0
30	0	0	0	0	0
40	0	0	0	0	0

Larvae emerged only at 25°C and the incubation period was more than 20 but shorter than 48 days (Table 6.9A). A temperature of 10°C was possibly too low for the hatching of eggs, while 30 and 40°C were too high.

During each observation dead eggs were also counted and the results are shown in Table 6.9B.

Table 6.9B : Total number of dead eggs of M. vredendalensis out of 75 per treatment at certain periods after oviposition at different temperatures and a constant soil moisture.

Temperature °C	Number of dead eggs After 20 days	After 34 days	After 41 days	After 48 days	After 55 days
10	36	55	60	63	65
25	36	63	68	70	-
30	53	72	75	-	-
40	75	-	-	-	-

The results in Table 6.9B show that 100 per cent of the eggs were dead at 40°C after 20 days, while 96 per cent were dead at 30°C after 34 days. These temperatures were evidently too high for the normal development of eggs to larvae. Although 75 per cent of the eggs were dead after 34 days at 10°C, 100 per cent mortality was reached only after 62 days.

Eggs were thus not killed at a temperature of 10°C but as already mentioned in paragraph 6.4.2 it was evidently too low for their development. Eggs hatched only at a temperature of 25°C, indicating that at this temperature the eggs can develop normally.

These results of the influence of temperature at a constant soil moisture were similar to those obtained for M. capensis under the same conditions (par. 4.4.4).

In the results of the incubation of eggs (par. 6.4), the percentage of eggs that hatched was often very low, even at apparently favourable conditions. The percentage of eggs of M. capensis that hatched under the same conditions was also very low (par. 4.4). This was probably partly due to the fact that the eggs were removed manually and were often disturbed during observations.

As mentioned in paragraph 4.1.3 intervals between observations were kept relatively long in order to reduce disturbance of eggs and conditions in the desiccators and the exact incubation period could therefore not be determined. This period was, however, more accurately determined in a succeeding experiment. Four hundred one day old eggs were placed in embryonic watch glasses and kept at 25°C in desiccators with a constant relative humidity of 100 per cent. After a period of 20 days the eggs were observed every second or third day and emerging larvae were counted and removed. Of the total number of eggs 77,0 per cent hatched, the rest being dead after 58 days. The incubation period was between 36 and 45 days. Of the total number of eggs hatched 92,7 per cent hatched between the 37th and 42nd day after oviposition.

7. BIOLOGY OF MARGARODES VREDENDALENSIS UNDER FIELD CONDITIONS

7.1 MATERIAL AND METHODS

To determine the vertical distribution of M. vredendalensis in the soil, observations were made in a seven year old, infested vineyard at the farm Liebendal near Vredendal in the Olifants River irrigation area. The vineyard was irrigated every 16 days by flood irrigation and observations were made 6 days after a normal irrigation. Regardless of vigour three vines were chosen at random during January 1976. A ditch, 45 cm wide 1,5 m long and 1,2 m deep, was dug at right angles with the vine rows and 30 cm away from each of the three vines.

Layers of soil, each 15 cm deep, were removed from the end of the ditch towards the vine to a depth of 1,2 m. Of the total amount of soil from each layer, small quantities were taken at random to obtain a sample of three or four litres. In the laboratory one litre of soil was taken at random from this sample and washed with water through three sieves with apertures of 2,8; 2,0 and 1,0 mm respectively. The cysts in each sieve were removed and those with an emergence orifice (empty cysts) were separated from the others and counted. The total number of the remaining cysts from each sieve was then counted. As the majority of live cysts sank in water, the percentage mortality could also be determined. The adult females in each sieve were removed and counted.

During excavations in the field, a small quantity of soil from each layer was placed in an airtight container. The percen-

tage moisture content of the soil was determined on a dry mass basis as described by Gardner (1965).

At each of the three vines a soil sample was also taken at each layer down to 1,2 m for soil analysis. The soil from each layer was bulked and analysed by the soil science section of the Viticultural and Oenological Research Institute according to the hydrometer method of Day (1956). The percentage coarse sand (2,0 - 0,5 mm), medium sand (0,5 - 0,21 mm), fine sand (0,21 - 0,02 mm), silt (0,02 - 0,002 mm) and clay (<0,002 mm) of each sample were determined.

7.2 VERTICAL DISTRIBUTION IN THE SOIL

To determine the vertical distribution of cysts, adult females and empty cysts, the average number per vine for each of the layers to a depth of 1,2 m was determined.

7.2.1 VERTICAL DISTRIBUTION OF CYSTS

The average number of cysts of all sizes per vine at the various depths, is shown in Figure 7.1. As can be seen from the graph the number of cysts was at a very low level in the upper 15 cm of soil, increasing gradually to reach a peak at a depth of 46 - 60 cm. In the following layers it decreased again gradually and at a depth of 91 - 120 cm, cysts occurred only in limited numbers.

As shown in Figure 7.2A, the distribution in depth of cysts greater than 2,8 mm in diameter was almost the same as that of cysts of all sizes together with a peak at a depth of 46 - 60 cm. The total number of cysts of the size range 2,8 - 2,0 mm was very low in the first 30 cm of soil, increasing sharply,

FIG. 7.1 : AVERAGE NUMBER OF CYSTS (ALL SIZES) PER VINE OF M. VREDENDALENSIS AT VARIOUS DEPTHS ON THE SOIL TO 1,2 M SAMPLED IN VREDENDAL DURING JANUARY 1976 AT THREE VINES.

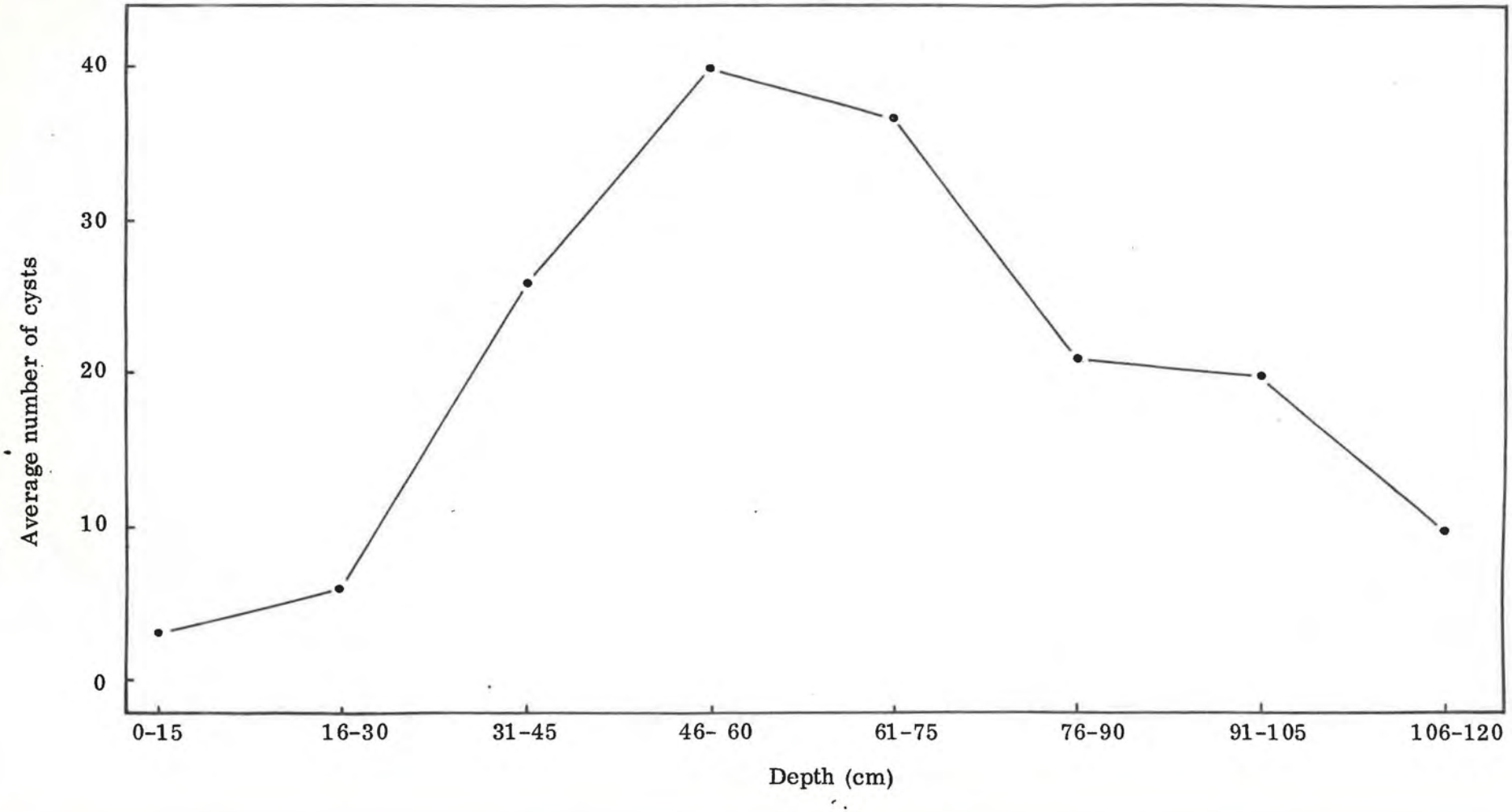
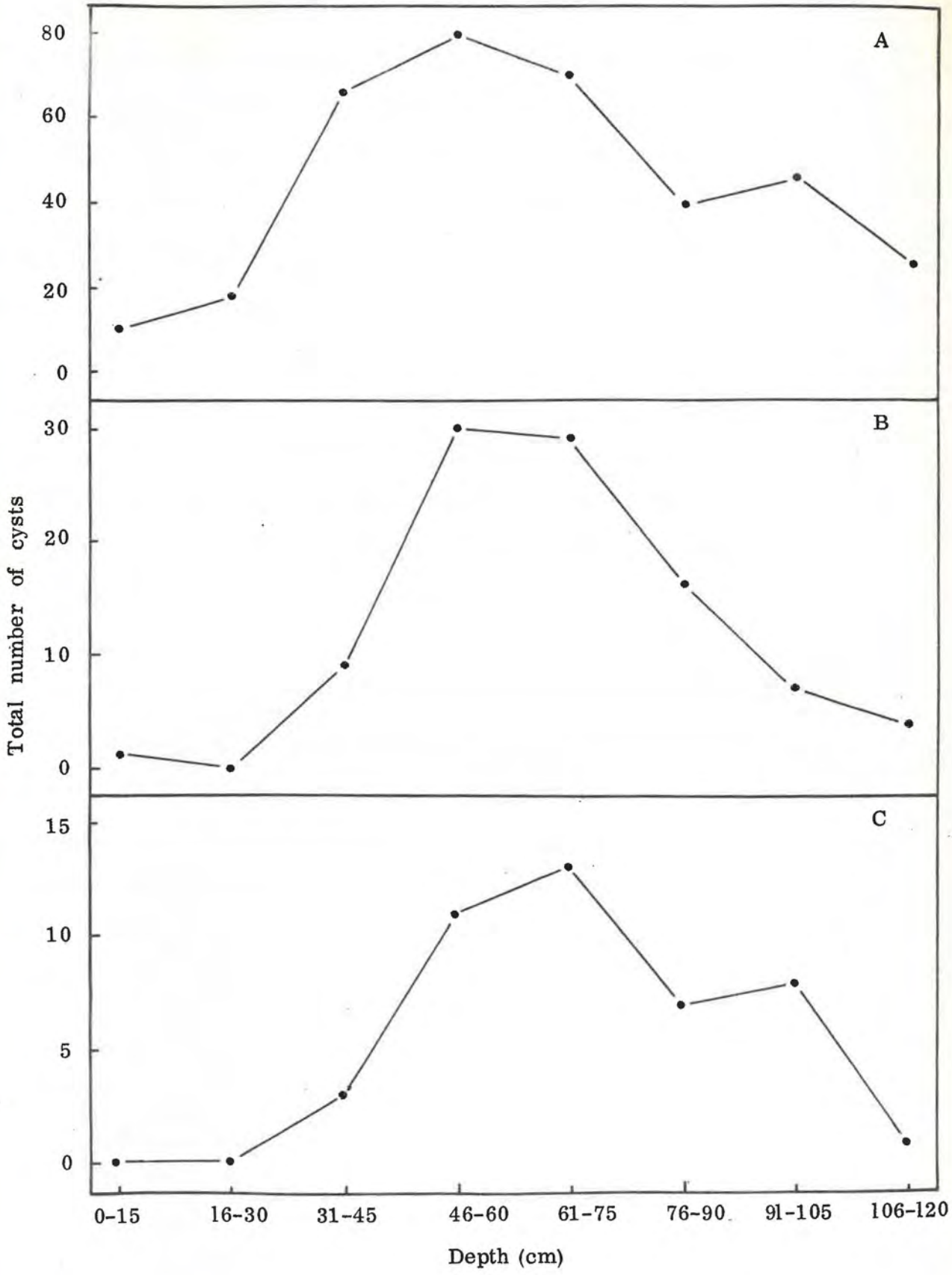


FIG. 7.2 : TOTAL NUMBER OF CYSTS OF M. VREDENDALENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN VREDENDAL DURING JANUARY 1976 AT THREE VINES (A) CYSTS GREATER THAN 2,8 MM (B) CYSTS 2,8 - 2,0 MM AND (C) CYSTS 2,0 - 1,0 MM IN DIAMETER.



to reach a peak at a depth of 46 - 60 cm. In the following layers their numbers decreased gradually and at a depth of 91 - 120 cm it occurred only in limited numbers (Fig. 7.2B). The vertical distribution of cysts of the size range 2,0 - 1,0 mm followed almost the same pattern as that of cysts in the size range 2,8 - 2,0 mm, with a peak at a depth of 61 - 75 cm (Fig. 7.2C). Evidently little differences occur in the vertical distribution of cysts of various sizes.

The average root mass per vine at each of the eight layers of soil down to a depth of 1,2 m was determined. The results are shown in Figure 7.3. In the upper 15 cm of soil the root mass was very low, increasing gradually to reach a peak at a depth of 46 - 60 cm. In the following layers it decreased again gradually and at a depth of 91 - 120 cm the root mass was very low. A comparison between Figure 7.1 and Figure 7.3 shows that the vertical distribution of cysts followed almost the same pattern as that of root mass with a peak at a depth of 46 - 60 cm. The relationship between the number of cysts and root mass was analysed statistically and the linear regression coefficient determined. A highly significant ($<0,01$) positive correlation was found between the number of cysts and the root mass ($r=0,5711$; $y=9,14 + 0,59x$; Fig. 7.4).

The relationship between the number of cysts and the percentage of each of the various soil fractions were analysed statistically and the linear regression coefficient determined. No significant correlation at the 5% level was found between the number of cysts and the percentage coarse sand ($r=0,0824$), medium sand ($r=0,2342$), fine sand ($r=0,0859$), medium plus fine

FIG. 7.3 : AVERAGE ROOT MASS PER VINE AT VARIOUS DEPTHS TO 1,2 M SAMPLED IN VREDENDAL DURING JANUARY 1976 AT THREE VINES.

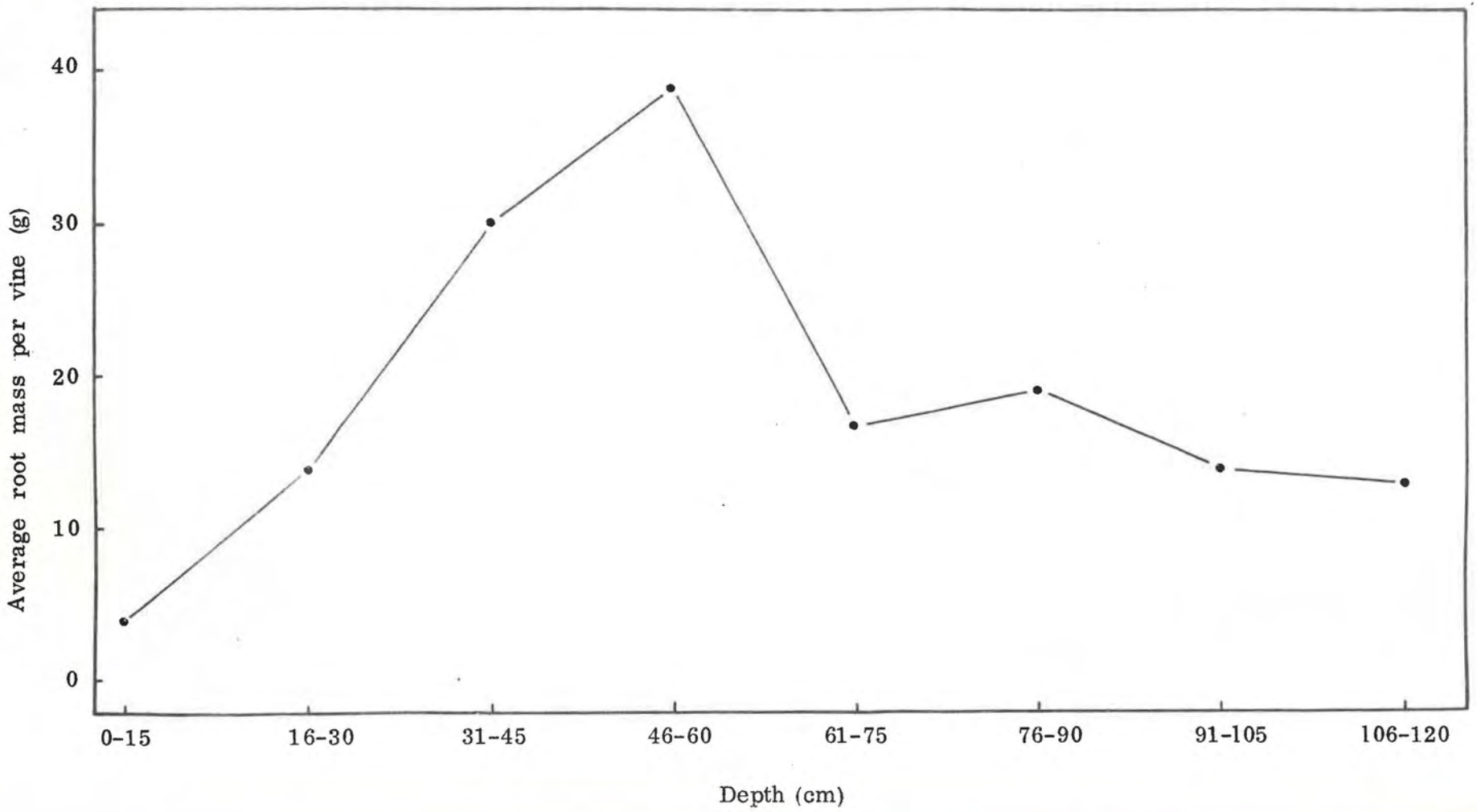
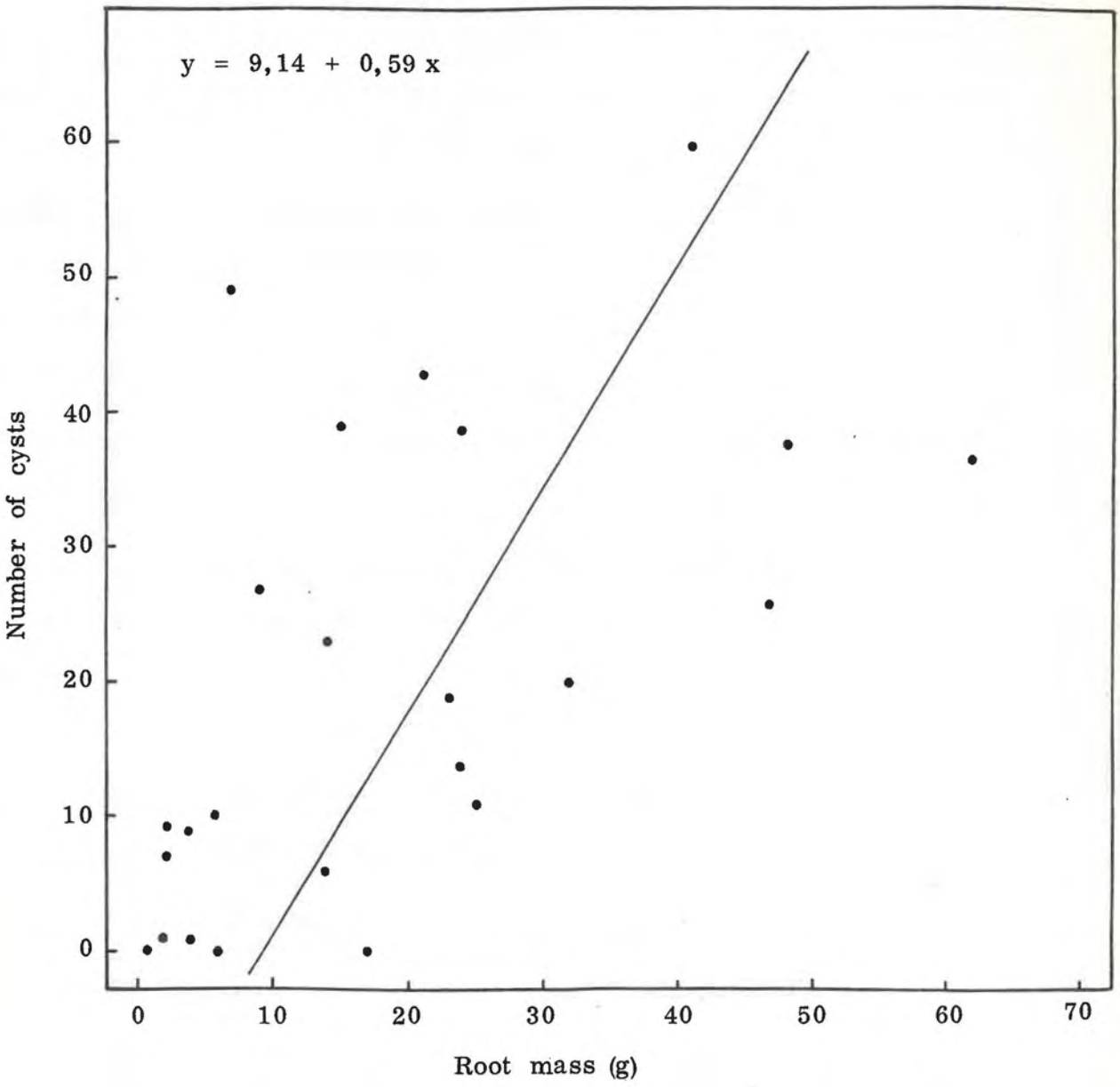


FIG. 7.4 : SCATTER DIAGRAM OF NUMBER OF CYSTS OF M. VREDENDALENSIS TO ROOT MASS.



sand (r=0,0655), silt (r=0,1690) and silt plus clay (r=0,0332). A significant ($P<0,05$) correlation was, however, found between the number of cysts and the percentage clay fraction of the soil (r= -0,4056; y=47,23 - 1,88x). The average percentage clay at the various depths is shown in Figure 7.5. The percentage clay was high in the upper 15 cm of soil, decreasing gradually to a minimum at a depth of 46 - 60 cm. In the following layers it increased again gradually. A comparison between Figures 7.1 and 7.5 shows clearly that the number of cysts increases as the percentage clay decreases and vice versa, as also indicated by the negative sample correlation coefficient (r).

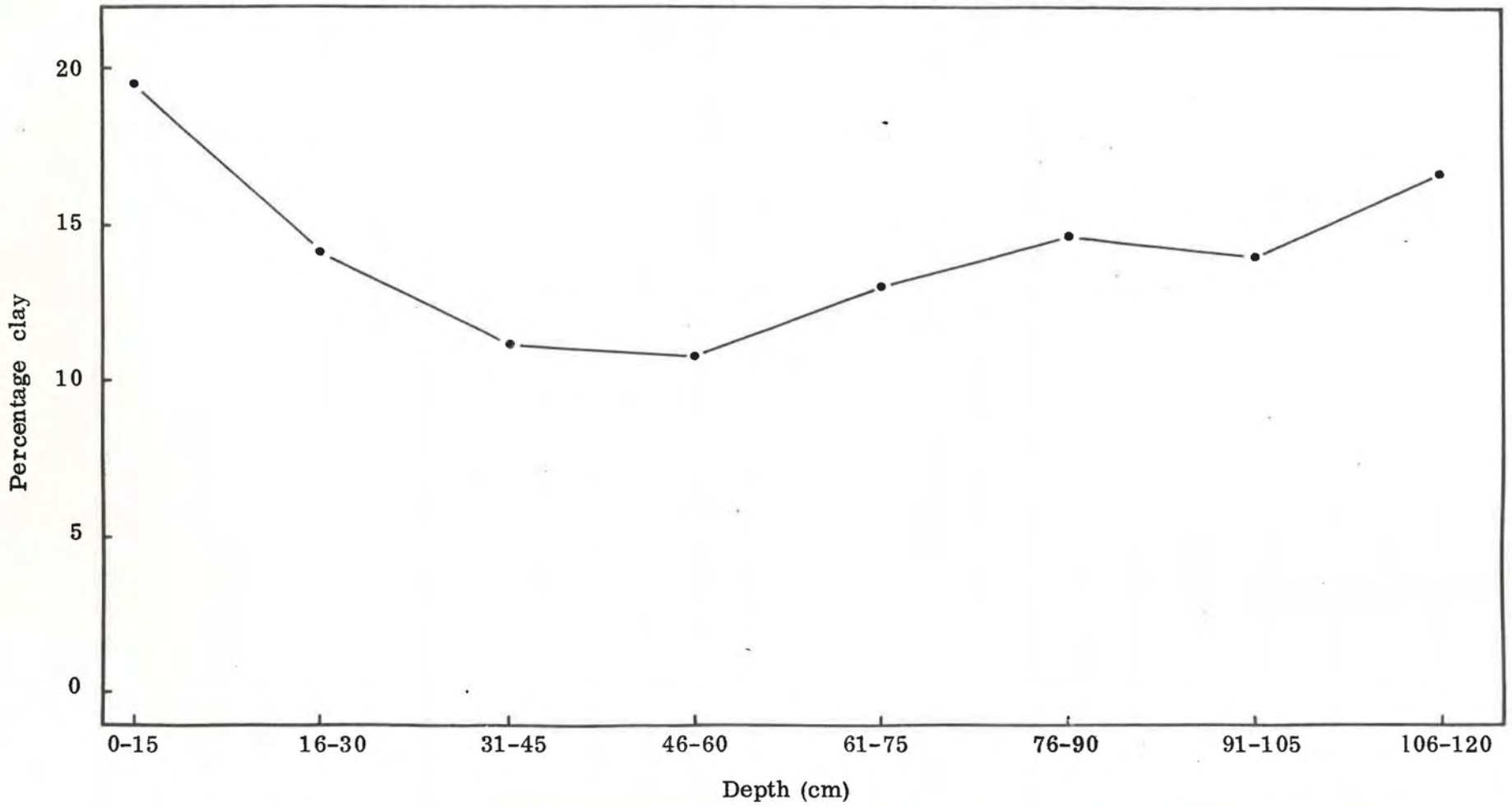
The percentage soil moisture content at each of the eight layers of soil to a depth of 1,2 m per vine, is given in Table 7.1.

Table 7.1 : Percentage soil moisture content per vine at various depths in the soil.

Replicate	Depths (cm)							
	0-15	16-30	31-45	46-60	61-75	76-90	91 - 105	106 - 120
I	9,40	7,23	4,20	5,52	5,57	6,00	6,62	5,00
II	9,26	8,81	6,54	7,41	6,22	6,71	6,79	5,77
III	8,96	8,51	8,01	6,07	7,60	7,03	8,41	7,44
Average	9,20	8,18	6,25	6,33	6,46	6,58	7,27	6,07

The table shows that the percentage soil moisture was at its lowest at a depth of 31 - 60 cm. In the first 30 cm of soil it was much higher, possibly due to the fact that observations

FIG. 7.5 : PERCENTAGE CLAY AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M IN VREDENDAL.



were made only 6 days after an irrigation. In the layers between 61 and 120 cm the percentages were slightly higher than at a depth of 31 - 60 cm. A linear regression coefficient was determined between the number of cysts and the percentage soil moisture for each of the various depths and a significant ($P<0,05$) correlation was found ($r= -0,4805$). The negative correlation coefficient indicates that the number of cysts decreases as the percentage soil moisture increases and vice versa ($\dot{y}=63,19 - 6,08x$).

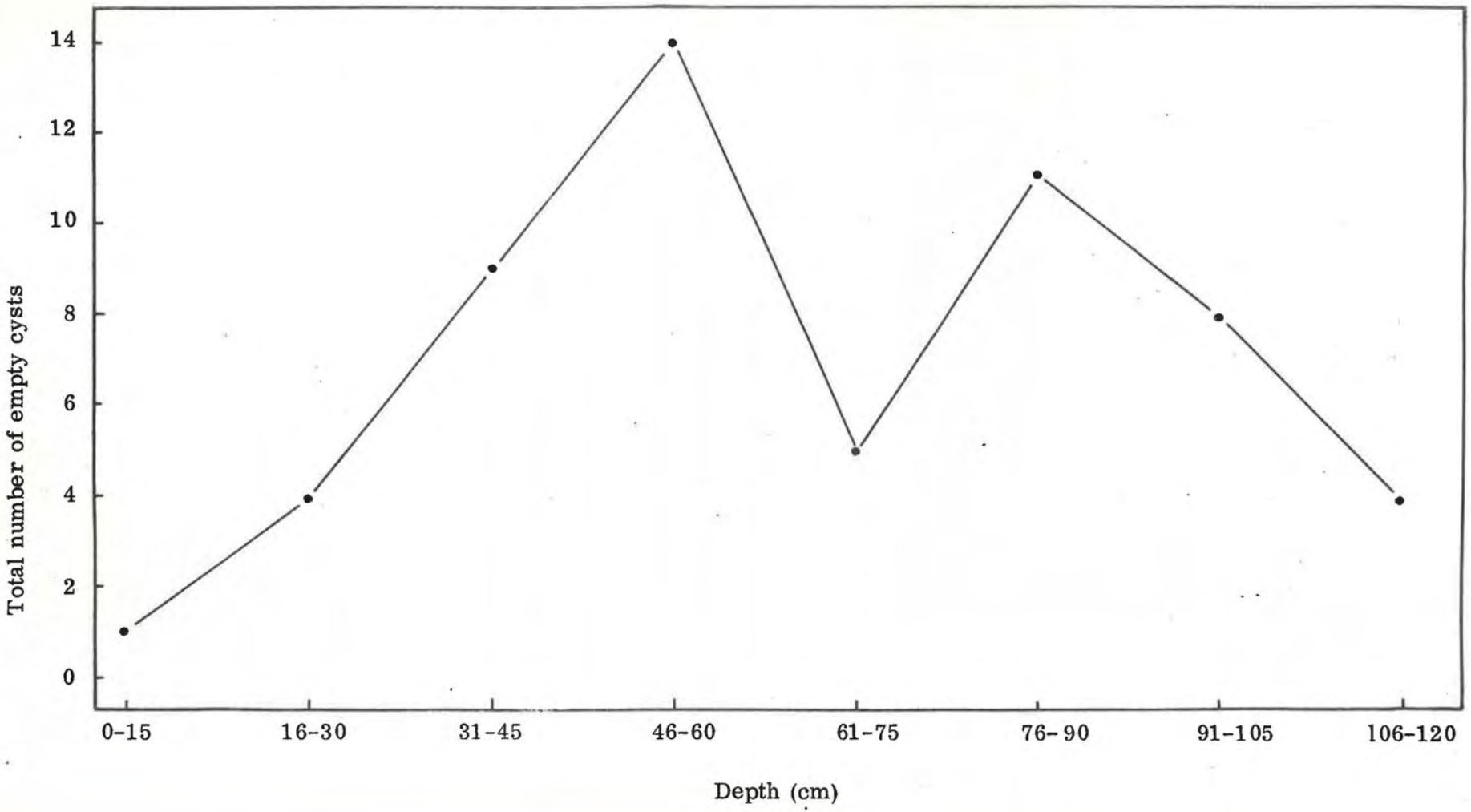
Although no causal relationship could be determined, root mass, percentage clay content of the soil and soil moisture could be direct factors influencing the vertical distribution of cysts or the percentage clay and soil moisture could be indirect factors by influencing the vertical distribution of roots.

The percentage dead cysts of each of the three size ranges and at each of the various depths was determined. As the figures of the different size ranges were almost similar, cysts of all sizes were taken together and their mortality at different depths compared. An analysis of variance showed no differences at the 5% level ($F=0,5358$), indicating that the normal mortality of cysts is at the same level from 0 - 1,2 m in the soil. The average percentage mortality of cysts was 18,81.

7.2.2 VERTICAL DISTRIBUTION OF EMPTY CYSTS

The total number of empty cysts (all sizes) at the various depths in the soil is shown in Figure 7.6. Empty cysts occurred in very low numbers in the upper 15 cm of soil, their numbers increasing gradually to a peak at a depth of 46 - 60 cm. In the following layers to a depth of 1,2 m, their numbers

FIG. 7.6 : TOTAL NUMBER OF EMPTY CYSTS PER VINE OF M. VREDENDALENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN VREDENDAL DURING JANUARY 1976 AT THREE VINES.



decreased again. A comparison between Figure 7.1 and Figure 7.6 indicates that the vertical distribution of live cysts and that of empty cysts followed almost the same pattern with a peak at a depth of 46 - 60 cm.

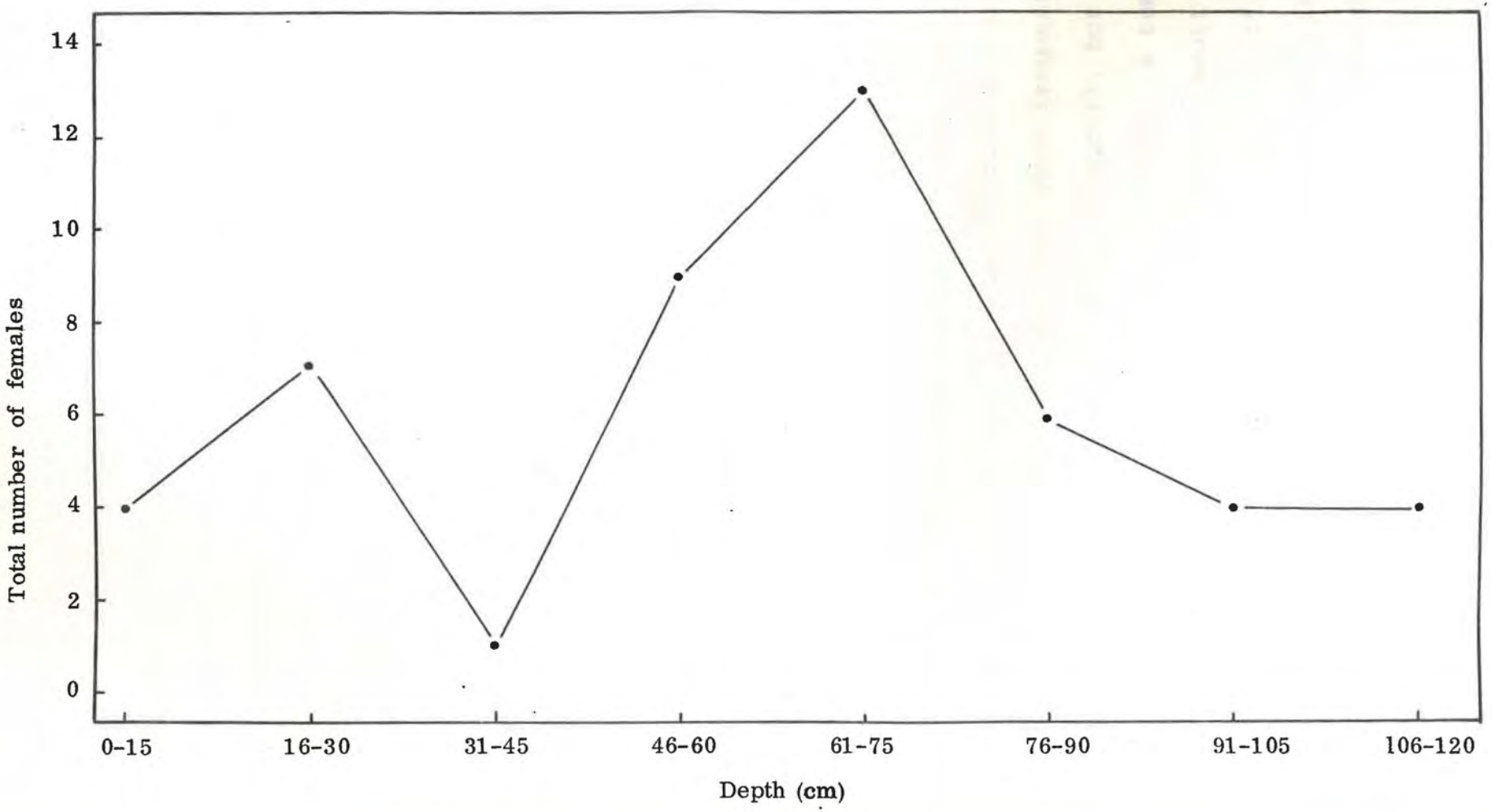
7.2.3 THE VERTICAL DISTRIBUTION OF ADULT FEMALES

The total number of adult females obtained at the three vines investigated and at the various depths in the soil, is shown in Figure 7.7. Their numbers were low in the first 45 cm of soil, increasing to a peak at a depth of 61 - 75 cm. In the following layers their numbers decreased again and at a depth of 106 - 120 cm it was at a low level.

The number of females and the percentage of each of the various soil fractions were analysed statistically and a linear regression coefficient determined. No significant correlation was found at the 5% level between the number of females and the percentage coarse sand (r=0,3099), medium sand (r= -0,3318), fine sand (r=0,0023), medium plus fine sand (r= -0,0827), silt (r=0,2585), clay (r=0,0067) and silt plus clay (r=0,1541). No significant ($P<0,05$) correlation was found between the number of females and the distribution of roots according to root mass (r=0,1022), soil moisture (r= -0,2222) or even the number of cysts (r=0,2474) and the number of empty cysts (r=0,0314).

Only three vines were investigated and the number of females found was very low, possibly resulting in the negative results mentioned above.

FIG. 7.7 : TOTAL NUMBER OF ADULT FEMALES PER VINE OF M. VREDENDALENSIS AT VARIOUS DEPTHS IN THE SOIL TO 1,2 M SAMPLED IN VREDENDAL DURING JANUARY 1976 AT THREE VINES.



8. SUMMARY

1. Detailed morphological redescriptions were made of seven Margarodes species occurring on grasses and vines in South Africa. Two new species, viz. M. upingtonensis (on kikuju) and M. vredendalensis (on vines) were also described. Keys are given to the nymphs of the cysts stage of six species and to the adult females of ten species.

2. The distribution of all the South African species of Margarodes with special reference to those infesting vines, is described.

3. Various aspects of the biology of M. capensis were investigated under laboratory and controlled conditions. Adult females emerged from cysts from the end of November to the beginning of March. Peaks of emergence occurred during the third week of January or at the middle of February. Only 3 to 10 per cent of cysts developed into adult females annually. Females emerged during four successive years from a collection of cysts, even if the cysts were detached from their host plant and did not feed. Emergence was more frequent from larger cysts (greater than 2,8 mm in diameter), but females also emerged from small cysts (2,0 - 1,0 mm). A temperature of 10°C was found to inhibit the emergence of adult females and at 40°C all the cysts were killed. The time of emergence was not influenced by other moderate temperatures tested and the dormancy of cysts could not be broken by moderate temperatures.

The pre-oviposition period lasted an average of 9 days during which time the females did not migrate to the soil surface

for mating since they reproduce parthenogenetically. The average oviposition period was 11 days and the average life-span 24 days. An average of 251 eggs was oviposited per female, the highest number being laid during the first four days. The total number of eggs oviposited per female as well as the average number per day was found to increase with increasing body mass of the females. At a constant humidity eggs were produced at 25 and 35°C, but oviposition was inhibited by a temperature of 10°C and at 40°C the females were killed. Eggs were also produced normally at relative humidities of 32,5 and 75,5 per cent. Oviposition was not markedly influenced by soil moisture but the number of eggs produced at a moisture content of 2 per cent could be lower than that at percentages between 6 and 30. Eggs were produced when the percentage soil moisture exceeded field-capacity and even when it was near the saturation percentage.

Eggs hatched at a relative humidity of 100 per cent but humidities of 75,5 and 32,5 per cent were too low for the normal development of eggs to larvae. Incubation of eggs was inhibited at 10°C and at 40°C the eggs were killed. Normal development of eggs to larvae was obtained at 25 and 30°C. Eggs hatched in very dry soil (2% soil moisture content) but the percentage that hatched increased at higher soil moisture contents. Eggs also hatched in wet soil of which the percentage moisture content exceeded field-capacity. Hatching took place even at saturation percentage. The mortality of eggs was lower in wet than in dry soils. In soil with a constant moisture content, eggs hatched only at 25°C. At a temperature of 10°C, incubation was again inhibited while the eggs

were killed at 30 and 40°C. At a constant relative humidity of 100 per cent and a constant temperature of 25°C the incubation period was between 34 and 43 days and the maximum percentage of eggs that hatched was 56,8 over a period of 49 days.

First instar larvae were covered with a cyst wall after two months and moulting to the cyst stage occurred between two and three months after hatching from the eggs.

4. With studies on the biology of M. capensis under field conditions, the following aspects were evident: cysts of all sizes including small cysts (1,0 - 2,0 mm in diameter), occurred throughout the year indicating that cysts cannot develop to the maximum size within one year and that the whole population does not develop into adult females during a period of one year. Empty cysts (cysts with an emergence orifice) of all sizes were also found throughout the year, indicating that they can remain in the soil without decaying for periods longer than one year. The occurrence of small empty cysts indicates that adult females can emerge without the cysts reaching the maximum size.

Adult females occurred from the middle of December to the end of May with a peak from the end of February to the middle of March. The maximum, mean and minimum daily air temperature per month did not directly influence the seasonal occurrence of females, although a peak in their numbers did appear when the maximum monthly temperature increased above 29°C. Although females occurred when the soil moisture content was very low, this factor did not directly influence the peak in the emergence of females.

A peak in the number of eggs produced occurred at the end of February. First instar larvae were found from the end of February to the end of May, their numbers reaching a peak in the middle of May. This peak was reached after the first autumn rains when the soil moisture content was almost at its highest although it seems that the minimum air temperature must be higher than 10°C.

During the whole year of investigation no males or male pupae were found, indicating that females reproduce parthenogenetically.

The average percentage mortality of cysts of all sizes was 26,5. Mortality increased during the late summer and mid winter. This increased mortality could not be attributed to the moisture content of the soil but high maximum temperatures during summer as well as low minimum temperatures during winter could possibly be direct factors influencing the mortality.

Cysts of all sizes were found at any depth to 1,2 m in the soil, the highest number occurring at a depth of 46 - 60 cm. The occurrence of cysts could be inhibited by very dry as well as very wet soil conditions but the peak in their numbers could not be attributed to the influence of soil moisture. The peak in the occurence of cysts was also not directly related to root mass. The vertical distribution pattern of cysts was also not influenced by the texture of the soil. The normal mortality of cysts was almost at the same level from 0 to 1,2 m in the soil. The vertical distribution of empty cysts followed almost exactly the same pattern as that of live cysts.

Adult females and eggs occurred at any depth to 1,05 m in the soil, the highest number occurring at a depth of 16 to 75 cm. First instar larvae were found from a depth of 16 cm to 1,2 m in the soil.

5. With studies under laboratory and controlled conditions with M. vredendalensis, the following was evident : adult females emerged during January and February, their numbers reaching a peak during the first week of February. Only 10 to 16 per cent of cysts developed into adult females annually. Females emerged during four successive years from a collection of cysts, even if the cysts were detached from their host plant and did not feed.

The pre-oviposition period lasted an average of 15 days during which time the females did not migrate to the soil surface for mating because they reproduce parthenogenetically. The average oviposition period of females was 18 days and their average lifespan 40 days. An average of 507 eggs was oviposited per female, the highest number being produced during the first 9 days. The total number of eggs oviposited per female as well as the average number per day increased with increasing body size of the females.

At a constant relative humidity as well as at a constant soil moisture content, oviposition was inhibited at a temperature of 10°C while at 40°C the females were killed. Eggs were, however, produced normally at 25 and 30°C. Although eggs were oviposited at relative humidities of 32,5 and 75,5 per cent, fewer eggs were produced at the lower percentage. The influence of soil moisture on oviposition was the same as that described for M. capensis.

The influence of relative humidity, temperature, soil moisture and temperature at a constant soil moisture content on M. vredendalensis were similar to those obtained for M. capensis under the same conditions.

6. With studies on the biology of M. vredendalensis under field conditions, the following aspects were evident : cysts were found at any depth to 1,2 m in the soil, the highest number occurred at a depth of 46 - 60 cm. The vertical distribution of cysts was directly related to the vertical distribution of roots. A significant correlation was found between the number of cysts and the percentage clay fraction of the soil : as the percentage clay decreased the number of cysts increased. The vertical distribution pattern of cysts was not influenced by other soil fractions. A significant correlation was also found between the distribution of cysts and soil moisture - as the percentage soil moisture increased the number of cysts decreased. The average percentage mortality of cysts was 18,8 and mortality was at the same level from 0 to 1,2 m in the soil. The vertical distribution of empty cysts followed almost the same pattern as that of live cysts.

Adult females were found at any depth to 1,2 m in the soil, the highest number occurring at a depth of 61 - 75 cm.

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